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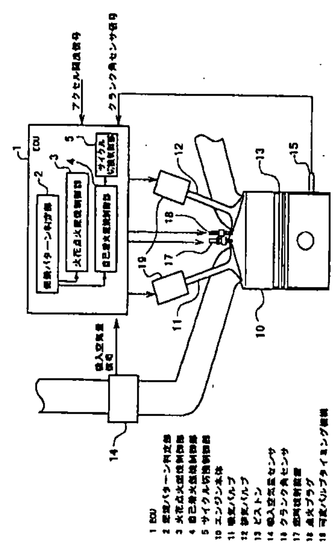
(54)【発明の名称】内燃機関の燃焼制御装置

(57)【要約】
【課題】　圧縮自己着火燃焼による運転範囲を高負荷側及び低負荷側に拡大することのできる内燃機関の燃焼制御装置を提供する。
【解決手段】　ECU1はアクセル開度信号及びクランク角センサ信号に基づいて要求負荷T及び機関回転数Nを算出し、この算出結果に基づいて燃焼パターン判定部2により火花点火燃焼か自己着火燃焼かの燃焼パターンを判定する。自己着火燃焼と判定したとき、自己着火燃焼制御部4は、吸気行程、圧縮行程、膨張行程、及び排気行程からなる第1の4行程サイクル運転と、吸気圧縮行程、膨張行程、圧縮行程、及び膨張排気行程からなり4行程サイクル中に2回の燃焼を行う第2の4行程サイクル運転と選択し、サイクル切換制御部5は可変バルブタイミング機構19を制御して第1又は第2の4行程サイクルのための吸排気弁タイミングを実現する。



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【特許請求の範囲】
【請求項1】　筒内に直接燃料を噴射する燃料直噴装置と吸排気弁の開閉時期を変更可能な可変動弁装置とを備え、運転条件に応じて圧縮自己着火燃焼と火花点火燃焼とを切換可能な内燃機関において、
吸気行程、圧縮行程、膨張行程、及び排気行程からなる第1の4行程サイクル運転と、吸気圧縮行程、膨張行程、圧縮行程、及び膨張排気行程からなり4行程サイクル中に2回の燃焼を行う第2の4行程サイクル運転とを圧縮自己着火燃焼時に切り換え可能としたことを特徴とする内燃機関の燃焼制御装置。
【請求項2】　前記第2の4行程サイクル運転時に、前記2回の燃焼用の燃料噴射量の合計は、目標トルクに応じた燃料噴射量であることを特徴とする請求項1記載の内燃機関の燃焼制御装置。
【請求項3】　前記第2の4行程サイクル運転時に、前記吸気圧縮行程の終了までに筒内に吸入された空気量に対する前記2回の燃焼用の燃料噴射量の合計が理論空燃比となることを特徴とする請求項1または請求項2記載の内燃機関の燃焼制御装置。
【請求項4】　前記第2の4行程サイクル運転時に、前記吸気圧縮行程の終了までに筒内に吸入された空気量に対する前記2回の燃焼用の燃料噴射量の合計が成層空燃比となることを特徴とする請求項1または請求項2記載の内燃機関の燃焼制御装置。
【請求項5】　前記第2の4行程サイクル運転時に、前記吸気圧縮行程の終了までに筒内に吸入された空気量に対する前記2回の燃焼用の燃料噴射量の合計が理論空燃比となる量よりもさらにトルクが要求された場合、圧縮自己着火燃焼から通常の火花点火燃焼へ切り換えることを特徴とする請求項1ないし請求項4のいずれか1項記載の内燃機関の燃焼制御装置。
【請求項6】　吸気を過給する過給手段と、該過給手段の過給圧を制御する過給圧制御手段とを更に備え、
前記第2の4行程サイクル運転時に、筒内の空燃比が理論空燃比となるように前記過給圧制御手段が過給圧を制御することを特徴とする請求項1ないし請求項5のいずれか1項記載の内燃機関の燃焼制御装置。
【請求項7】　筒内に直接燃料を噴射する燃料直噴装置と吸排気弁の開閉時期を変更可能な可変動弁装置とを備え、1サイクル当たり6行程以上の行程を有する運転を行う内燃機関において、
前記サイクル中に、ガス交換を行うための吸排気バルブの開閉を1回とし、燃焼回数を前記サイクル当たりの行程数の1／2とすることを特徴とする内燃機関の燃焼制御装置。
【請求項8】　圧縮自己着火燃焼で6行程サイクル以上の運転時に、ガス交換後の筒内空気量に対する1サイクル当たりの燃料噴射量の合計を理論空燃比としたことを特徴とする請求項7記載の内燃機関の燃焼制御装置。

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【請求項9】　圧縮自己着火燃焼で6行程サイクル以上の運転時に、ガス交換後の筒内空気量に対する1サイクル当たりの燃料噴射量の合計を成層空燃比としたことを特徴とする請求項7記載の内燃機関の燃焼制御装置。
【発明の詳細な説明】
【0001】
【発明の属する技術分野】本発明は、運転条件に応じて火花点火燃焼と圧縮自己着火燃焼とを切り換え可能な内燃機関において、圧縮自己着火燃焼の1サイクル中の行程の構成を可変とした内燃機関の燃焼制御装置に関する。
【0002】
【従来の技術】ガソリンエンジンの熱効率を改善するために、混合気をリーン化することでポンプ損失を低減すると共に作動ガスの比熱比を大きくして理論熱効率を向上する手法が知られている。しかしながら、従来の火花点火エンジンでは空燃比をリーンにすると燃焼期間が長期化して、燃焼安定度が悪化する。このため、空燃比のリーン化には限界がある。
【0003】このような燃焼安定度の悪化を避けながら空燃比をリーン化する従来技術として、特開平7－71279号公報にあるように予混合圧縮自己着火燃焼を起こさせる2行程サイクルエンジンが開示されている。予混合圧縮自己着火燃焼では、燃焼室内の複数の位置から燃焼反応が起こるため、空燃比がリーン化した場合においても火花点火に比べると燃焼期間が長期化せずに、よりリーンな空燃比でも安定した燃焼が可能となる。また空燃比がリーンのため燃焼温度が低下し、NOxも大幅に低減できる。
【0004】また第2の従来例として特開平10－252511号公報には、ポート噴射の6行程サイクル運転機関が開示されている。第2の従来例では機関始動後に不完全燃焼が起こった場合、通常の4行程サイクル運転から、圧縮行程及び膨張（燃焼）行程の対が2回連続して繰り返される6行程サイクル運転に切り換えている。
【0005】さらに、第3の従来例としては、特開平5－240049号公報には、開閉可能な空気室弁により燃焼室に連通可能な空気室を備えた直噴式の6行程サイクル運転機関が開示されている。第3の従来例では、第1吸気行程、第1圧縮行程、第2吸気行程、第2圧縮行程、膨張（燃焼）行程、排気行程からなる6行程サイクル運転が示されている。
【0006】この6行程サイクルの第1圧縮行程は、高温、高圧に圧縮された空気を開閉可能な空気室弁を備えた空気室に一時的に貯留するためのものであり、第2吸気行程で燃焼室内の空気を補充し、第2圧縮行程により高温、高圧となった燃焼室に軽油を噴射して燃焼させ、膨張行程中に空気室より貯留された高圧の空気を噴出させて燃焼室内を撹拌することにより、燃焼を促進するものである。

【０００７】
【発明が解決しようとする課題】しかしながら、第１の従来例では通常の２行程サイクルエンジン構成としているためガス交換を制御する吸気バルブおよび排気バルブがなく、未燃焼ガスの吹き抜けが発生し燃費が悪化していた。また、ガス交換が２行程サイクル中に１回となっているため、未燃ＨＣの排出によりエミッションが悪化する可能性がある。また、膨張行程はガス交換を行う必要性から後半に排気を行う膨張排気行程となるので、燃焼ガスの膨張から十分仕事をとりだすことができないために、高負荷運転が困難であるという問題点があった。

【０００８】一方、自己着火燃焼は空燃比の影響を強く受ける。例えば、高負荷運転を考えて空燃比を濃くした場合には、燃焼反応を起こす燃料量が増加し、燃焼が激しくなりノッキングを起こす。従って、所定のレベル以下にノッキングを抑制するために筒内に送り込める燃料量が制限される。このため、燃焼回数が２回転に１回の通常の４行程サイクルエンジンでは、高負荷での自己着火燃焼による運転が困難であるという問題点があった。

【０００９】また第２の従来技術では、４行程サイクルから６行程サイクルに切り換えることができるが、燃料噴射がポート噴射であるため、２回目の燃焼サイクルでは新たな燃料を送り込むことができない。従って、不完全燃焼発生時のみに未燃の燃料により２回目の燃焼を実現することになる。このため負荷を向上させることが困難であるという問題点があった。

【００１０】また第３の従来技術では、６行程サイクル中のピストン下降行程は、第１及び第２の吸気行程と膨張行程となっているので、燃焼回数は膨張行程の１回のみとなり、燃焼ガスから仕事に十分に取り出すことができず、負荷を向上させることが困難であるという問題点があった。

【００１１】さらに、圧縮自己着火燃焼を成立させるためには、圧縮行程において、圧力および温度を高める必要があり、高圧縮比化が必要となるが、出力が要求される全負荷運転領域との両立性を考えた場合にはノッキングの抑制のため圧縮比をある程度下げる必要性があった。しかしながら、圧縮比を下げた場合においては自己着火燃焼が成立する負荷範囲が狭くなるという問題点があった。

【００１２】本発明はかかる問題点に鑑みたもので、その目的は、ノッキング及び燃焼不安定を回避しつつ、圧縮自己着火燃焼による運転範囲を高負荷側及び低負荷側に拡大することのできる内燃機関の燃焼制御装置を提供することである。また本発明の目的は、燃焼回数に対するガス交換回数を少なくすることによって、燃費、エミッションを改善し、熱効率が高くクリーンな内燃機関を提供することにある。

【００１３】
【課題を解決するための手段】請求項１記載の発明は、上記課題を解決するため、筒内に直接燃料を噴射する燃料直噴装置と吸排気弁の開閉時期を変更可能な可変動弁装置とを備え、運転条件に応じて圧縮自己着火燃焼と火花点火燃焼とを切換可能な内燃機関において、吸気行程、圧縮行程、膨張行程、及び排気行程からなる第１の４行程サイクル運転と、吸気圧縮行程、膨張行程、圧縮行程、及び膨張排気行程からなり４行程サイクル中に２回の燃焼を行う第２の４行程サイクル運転とを圧縮自己着火燃焼時に切り換え可能としたことを要旨とする。

【００１４】請求項２記載の発明は、上記課題を解決するため、請求項１記載の内燃機関の燃焼制御装置において、前記第２の４行程サイクル運転時に、前記２回の燃焼用の燃料噴射量の合計は、目標トルクに応じた燃料噴射量であることを要旨とする。

【００１５】請求項３記載の発明は、上記課題を解決するため、請求項１または請求項２記載の内燃機関の燃焼制御装置において、前記第２の４行程サイクル運転時に、前記吸気圧縮行程の終了までに筒内に吸入された空気量に対する前記２回の燃焼用の燃料噴射量の合計が理論空燃比となることを要旨とする。

【００１６】請求項４記載の発明は、上記課題を解決するため、請求項１または請求項２記載の内燃機関の燃焼制御装置において、前記第２の４行程サイクル運転時に、前記吸気圧縮行程の終了までに筒内に吸入された空気量に対する前記２回の燃焼用の燃料噴射量の合計が成層空燃比となることを要旨とする。

【００１７】請求項５記載の発明は、上記課題を解決するため、請求項１ないし請求項４のいずれか１項記載の内燃機関の燃焼制御装置において、前記第２の４行程サイクル運転時に、前記吸気圧縮行程の終了までに筒内に吸入された空気量に対する前記２回の燃焼用の燃料噴射量の合計が理論空燃比となる量よりもさらにトルクが要求された場合、圧縮自己着火燃焼から通常の火花点火燃焼へ切り換えることを要旨とする。

【００１８】請求項６記載の発明は、上記課題を解決するため、請求項１ないし請求項５のいずれか１項記載の内燃機関の燃焼制御装置において、吸気を過給する過給手段と、該過給手段の過給圧を制御する過給圧制御手段とを更に備え、前記第２の４行程サイクル運転時に、筒内の空燃比が理論空燃比となるように前記過給圧制御手段が過給圧を制御することを要旨とする。

【００１９】請求項７記載の発明は、上記課題を解決するため、筒内に直接燃料を噴射する燃料直噴装置と吸排気弁の開閉時期を変更可能な可変動弁装置とを備え、１サイクル当たり６行程以上の行程を有する運転を行う内燃機関において、前記サイクル中に、ガス交換を行うための吸排気バルブの開閉を１回とし、燃焼回数を前記サイクル当たりの行程数の１／２とすることを要旨とする内燃機関の燃焼制御装置である。

【００２０】請求項８記載の発明は、上記課題を解決するため、請求項７記載の内燃機関の燃焼制御装置において、圧縮自己着火燃焼で６行程サイクル以上の運転時に、ガス交換後の筒内空気量に対する１サイクル当たりの燃料噴射量の合計を理論空燃比としたことを要旨とする。

【００２１】請求項９記載の発明は、上記課題を解決するため、請求項７記載の内燃機関の燃焼制御装置において、圧縮自己着火燃焼で６行程サイクル以上の運転時に、ガス交換後の筒内空気量に対する１サイクル当たりの燃料噴射量の合計を成層空燃比としたことを要旨とする。

【００２２】
【発明の効果】請求項１記載の本発明によれば、筒内に直接燃料を噴射する燃料直噴装置と吸排気弁の開閉時期を変更可能な可変動弁装置とを備え、運転条件に応じて圧縮自己着火燃焼と火花点火燃焼とを切換可能な内燃機関において、吸気行程、圧縮行程、膨張行程、及び排気行程からなる第１の４行程サイクル運転と、吸気圧縮行程、膨張行程、圧縮行程、及び膨張排気行程からなり４行程サイクル中に２回の燃焼を行う第２の４行程サイクル運転とを圧縮自己着火燃焼時に切り換え可能としたので、第２の４行程サイクル運転の領域では、通常の４行程サイクルエンジンに対しては、エンジン回転当たりの燃焼回数を２倍に増加することができるため、より高負荷域においての圧縮自己着火運転すなわち高効率、クリーンな運転が可能となり、燃費、エミッションが改善できる。また通常の２行程サイクルエンジンに対しては燃焼回数に対するガス交換回数を１／２に減らすことができるため、燃費、エミッションを改善することができる。

【００２３】請求項２記載の本発明によれば、請求項１記載の発明の効果に加えて、前記第２の４行程サイクル運転時に、前記２回の燃焼用の燃料噴射量の合計は、目標トルクに応じた燃料噴射量としたので、目標トルク通りの出力トルクを得ることができ、運転性のよい内燃機関を提供することができる。

【００２４】請求項３記載の本発明によれば、請求項１または請求項２記載の発明の効果に加えて、前記第２の４行程サイクル運転時に、前記吸気圧縮行程の終了までに筒内に吸入された空気量に対する前記２回の燃焼用の燃料噴射量の合計が理論空燃比となるようにしたので、内燃機関から排出されるガスの空燃比も常に理論空燃比となり、排気を浄化する三元触媒を効率よく作用させ、排気を極めて清浄化するとともに、高効率な運転が可能となる。

【００２５】請求項４記載の本発明によれば、請求項１または請求項２記載の発明の効果に加えて、前記第２の４行程サイクル運転時に、前記吸気圧縮行程の終了までに筒内に吸入された空気量に対する前記２回の燃焼用の燃料噴射量の合計が成層空燃比となるようにしたので、燃費をさらに改善することができる。

【００２６】請求項５記載の本発明によれば、請求項１ないし請求項４のいずれか１項記載の発明の効果に加えて、内燃機関の燃焼制御装置において、前記第２の４行程サイクル運転時に、前記吸気圧縮行程の終了までに筒内に吸入された空気量に対する前記２回の燃焼用の燃料噴射量の合計が理論空燃比となる量よりもさらにトルクが要求された場合、圧縮自己着火燃焼から通常の火花点火燃焼へ切り換えることにより、内燃機関より排出される燃焼ガスがストイキよりもリッチとなり、三元触媒が有効活用できずにエミッションが悪化することを防ぐことができる。

【００２７】請求項６記載の本発明によれば、請求項１ないし請求項５のいずれか１項記載の発明の効果に加えて、吸気を過給する過給手段と、該過給手段の過給圧を制御する過給圧制御手段とを更に備え、前記第２の４行程サイクル運転時に、筒内の空燃比が理論空燃比となるように前記過給圧制御手段が過給圧を制御するようにしたので、より高負荷域での圧縮自己着火運転すなわち高効率、クリーンな運転が可能となり、燃費、エミッションが改善できる。また、内燃機関より排出されるガスの空燃比が常に理論空燃比となるため、エミッションの浄化率の極めて高い三元触媒が活用できるようになり、エミッションを悪化することなく、高効率な運転が可能となる。

【００２８】請求項７記載の本発明によれば、筒内に直接燃料を噴射する燃料直噴装置と吸排気弁の開閉時期を変更可能な可変動弁装置とを備え、１サイクル当たり６行程以上の行程を有する運転を行う内燃機関において、前記サイクル中に、ガス交換を行うための吸排気バルブの開閉を１回とし、燃焼回数を前記サイクル当たりの行程数の１／２とすることによって、通常の４サイクル内燃機関に対しては内燃機関回転当たりの燃焼回数を２倍に増加することができるため、より高負荷域においての圧縮自己着火運転すなわち高効率、クリーンな運転が可能となり、燃費、エミッションが改善できる。またサイクル当たりのガス交換回数は１回であるため、内燃機関より排出されるエミッションを大幅に改善することができる。

【００２９】請求項８記載の本発明によれば、請求項７記載の発明の効果に加えて、圧縮自己着火燃焼で６行程サイクル以上の運転時に、ガス交換後の筒内空気量に対する１サイクル当たりの燃料噴射量の合計を理論空燃比としたことによって、ガス交換過程によって内燃機関より排出されるガスの空燃比は常に理論空燃比となるため、エミッションの浄化率の極めて高い三元触媒が活用できるようになり、エミッションを悪化することなく、高効率な運転が可能となる。

【００３０】請求項９記載の本発明によれば、請求項７記載の発明の効果に加えて、圧縮自己着火燃焼で６行程

サイクル以上の運転時に、ガス交換後の筒内空気量に対する１サイクル当たりの燃料噴射量の合計を成層空燃比としたことによって、燃費をさらに改善することができる。

【００３１】

【発明の実施の形態】以下、図面に基づいて本発明の実施の形態について説明する。図１は本発明に係る内燃機関の燃焼制御装置をガソリンエンジンに適用した第１の実施の形態の構成を示すシステム構成図である。

【００３２】本実施形態においては、運転条件に応じて圧縮自己着火燃焼と火花点火燃焼とを切換可能となっている。さらに圧縮自己着火燃焼においては、吸気行程、圧縮行程、膨張行程、及び排気行程からなる第１の４行程サイクル運転（通常の４行程サイクル）と、吸気圧縮行程、膨張行程、圧縮行程、及び膨張排気行程からなり４行程サイクル中に２回の燃焼を行う第２の４行程サイクル運転とを切り換え可能としていることが特徴である。

【００３３】図中のエンジン本体１０は、吸気バルブ１１、排気バルブ１２、ピストン１３、クランク角センサ１５、燃料噴射装置１７、点火プラグ１８、及び可変バルブタイミング機構１９を備えて構成されている。吸気系は吸気空気量センサ１４を有している。

【００３４】このエンジン本体１０を制御する電子制御装置（以下、ＥＣＵと略す）１は、運転条件に応じて圧縮自己着火燃焼と火花点火燃焼のいずれの燃焼方式で運転を行うかを判定する燃焼パターン判定部２、火花点火燃焼運転時の燃焼パラメータ制御する火花点火燃焼制御部３、圧縮自己着火燃焼運転時の燃焼制御パラメータを制御するとともに、圧縮自己着火燃焼運転を第１の４行程サイクル運転で行うか、第２の４行程サイクル運転で行うかを判定する自己着火燃焼制御部４、自己着火燃焼制御部４の判定に従って第１又は第２の４行程サイクル運転となるように、吸排気弁の開閉時期を変更したり、燃料噴射量及び燃料噴射タイミングを変更するサイクル切換制御部５を備えている。

【００３５】尚、ＥＣＵ１の構成要素、燃焼パターン判定部２、火花点火燃焼制御部３、自己着火燃焼制御部４、サイクル切換制御部５は、ハードワイヤードの論理回路で構成することもできるが、本実施の形態では、マイクロコンピュータのプログラムとして実現されている。

【００３６】またＥＣＵ１は、吸入空気量センサ１４が検出した吸入空気量信号、クランク角センサ１５が検出したエンジン回転数信号、及びアクセル開度センサ（図示せず）が検出したアクセル開度信号（負荷）に基づいて、運転条件を判定し、燃料噴射量、点火時期を算出する。そして、この算出結果に基づき、燃料噴射装置１７、点火プラグ１８に信号を送る。

【００３７】また、圧縮自己着火燃焼の場合、運転条件に応じて、第１の４行程サイクルと第２の４行程サイクルとを切り換えて、サイクル当たりの燃焼回数を変更する際には、可変バルブタイミング機構１９に信号を送り、バルブ開閉タイミングを切り換えるとともに、燃料噴射装置１７からのサイクル当たりの燃料噴射回数を変更することにより燃焼回数を変更する。

【００３８】このような構成のもと、本発明では、図２に示すような、中低負荷及び中回転数以下の特定の運転条件において圧縮自己着火燃焼を行い、高負荷または高回転数域において火花点火燃焼を行う。

【００３９】次に、本実施の形態の動作について説明する。図３は、空燃比に対する自己着火燃焼が成立する範囲を示すものである。空燃比をリーンにしていくと燃焼安定度が悪化し、機関のトルク変動が大きくなる。このため、内燃機関としての設計値、又はこの内燃機関を搭載した車両の性格等として許容できる安定度が安定度限界値Ｓｔｈとなる空燃比ＡＦＬがリーン限界となる。

【００４０】一方、空燃比をリッチにしていくと、ノッキング強度が増大する。これによりノッキング限界ＮｔｈにおけるFAIL空燃比ＡＦＲがリッチ限界となる。従って、安定度限界空燃比ＡＦＬとノッキング限界空燃比ＡＦＲで囲まれる空燃比領域が自己着火燃焼成立範囲となる。このように、自己着火は限られた空燃比範囲でしか成立しない。尚、ここではガスと燃料の割合を表す指標として空燃比Ａ／Ｆを例に説明した。残留ガスあるいはＥＧＲガスが含まれる場合についても同様の傾向を示し、この際には横軸は新気と既燃ガスを合わせたトータルのガス量と燃料の割合Ｇ／Ｆとなる。

【００４１】図４に、通常の４サイクルエンジンの４行程サイクルを示す。これは、本発明における第１の４行程サイクルと同じであり、吸気行程、圧縮行程、膨張行程および排気行程からなり、エンジン２回転に対して燃焼回数は１回である。

【００４２】図５に通常の４行程サイクル運転における自己着火燃焼運転範囲を示す。前述したように圧縮自己着火燃焼ではノッキングの発生を防ぐため、筒内に送り込める燃料量が制限される。従って、燃焼回数がエンジン２回転に対して１回の４行程サイクルエンジンでは仕事を取り出せる機会が少ないため負荷を増大することができない。このため高負荷域での自己着火燃焼による運転が困難である。

【００４３】図６に、２サイクルエンジンの２行程サイクルを示す。２行程サイクルは、吸気圧縮行程、膨張排気行程からなり、エンジン１回転に対して燃焼回数は１回である。図に示すように、膨張行程の途中から排気弁が開き、ガス交換が開始される。このため膨張行程中で十分に仕事を取り出すことができない。また未燃焼の燃料が排出されるため効率が低下する。よって、負荷を十分に向上させることができない。

【００４４】図７に２行程サイクル運転を行った場合の自己着火燃焼運転範囲を示す。図からわかるように、４行程サイクル運転よりは負荷を向上できるものの、燃焼回数が２倍になっているにもかかわらず、負荷を２倍にすることはできない。

【００４５】図８に本実施の形態における第２の４行程サイクルを示す。第２の４行程サイクルは、吸気圧縮行程、膨張行程、圧縮行程および膨張排気行程からなり、吸気圧縮行程における吸気弁閉弁後に１回目の燃料噴射、膨張行程で１回目の燃焼、圧縮行程で２回目の燃料噴射、膨張排気行程で２回目の燃焼を行うので、サイクル当たりの燃焼回数は２回となる。言い換えれば、燃焼回数はエンジン１回転当たり１回であり、２行程サイクルエンジンと同じである。またガス交換はエンジン２回転に１回であり、図４の４行程サイクルエンジンと同じである。

【００４６】図９に本実施の形態の第２の４行程サイクル中の筒内の成分割合を模式的に示す。前述したように圧縮自己着火燃焼は空燃比が極めてリーンな状態においても燃焼が可能である。従って、吸気圧縮行程中の燃料量は空気量に対して非常に少ない。また１回目の燃焼が終了した膨張行程においては、既燃ガスは存在するものの空燃比が極めてリーンのため空気が十分残っている。従ってガス交換をしなくとも後続の圧縮行程において２回目の燃料噴射により燃料を供給することにより、２回目の燃焼が可能となる。運転条件によっては２回目の燃焼が終了した後にも空気が存在することもあり得る。

【００４７】図１０は、第１及び第２の４行程サイクル運転におけるバルブタイミング（バルブリフト）を示す図であり、（ａ）サイクル当たり燃焼回数１回の第１の４行程サイクル運転と、（ｂ）サイクル当たり燃焼回数２回の第２の４行程サイクル運転をそれぞれ示す。このようにカムプロフィールの異なるカムを２式備えて、可変バルブタイミング機構によりカムを切り換えることによって、吸排気タイミングを変更し、第１の４行程サイクル運転と、第２の４行程サイクル運転とを切り換え、サイクル当たりの燃焼回数を変更することができる。なお、バルブタイミングの変更は電磁駆動バルブ（ Electromagnetic Valve) 等を用いても良い。

【００４８】図１１に、燃焼回数が１回の第１の４行程サイクル運転と、燃焼回数は２回の第２の４行程サイクル運転時の自己着火燃焼範囲を示す。第２の４行程サイクル運転では、サイクル当たり２回の燃焼中、１回目の燃焼である膨張行程では、吸排気弁が共に閉じてガス交換を行わないので、仕事を十分に取り出すことができる。

【００４９】また、２回目の燃焼である膨張排気行程では、１回目の燃焼で生成された既燃ガスによる内部ＥＧＲにより筒内の温度、圧力が向上しているため、燃焼が高効率化する。また、高温、高圧の筒内において１回目の燃焼で排出された未燃燃料を再度燃焼させることができると共に、２回目の燃焼では未燃燃料の発生は極めて少なくなる。以上の理由により２回目の燃焼も２行程サイクル運転時よりも効率を向上することができる。この結果、第２の４行程サイクル運転では、負荷も第１の４行程サイクル運転の略２倍に増加することができ、自己着火燃焼範囲を高負荷側に拡大することができる。

【００５０】図１２は、本実施の形態の制御の流れを示すフローチャートである。まずステップ１０（以下Ｓ１０）でアクセル開度信号、クランク角センサ信号を検出する。次いでＳ１１で上記検出結果をもとに要求エンジン回転数Ｎ、要求トルクＴを算出する。次いでＳ１２で火花点火燃焼を行うか、圧縮自己着火燃焼を行うかの燃焼パターンを判断する。

【００５１】すなわちエンジン回転数Ｎと負荷Ｔから、図１１に示したような運転領域マップを検索して、火花点火燃焼運転を行うか圧縮自己着火燃焼運転を行うか判断する。火花点火運転を行う場合にはＳ１３に進み、火花点火運転の制御を開始する。

【００５２】自己着火運転を行う場合にはＳ１４に進んで自己着火燃焼制御を開始する。次いでＳ１５で再度エンジン回転数Ｎと負荷Ｔを確認する。次いでＳ１６で燃焼回数を判断する。すなわちエンジン回転数Ｎと負荷Ｔから図１１のマップをもとに、第１の４行程サイクル運転を行うか、第２の４行程サイクル運転を行うかを判断する。言い換えれば４行程サイクル当たりの燃焼回数を判断する。第１の４行程サイクル、即ちサイクル当たりの燃焼回数が１回の場合には、Ｓ１７で図１０（ａ）に示すバルブタイミングに変更し、Ｓ１８で第１の４行程サイクル運転（図４）の制御を開始する。

【００５３】Ｓ１６でサイクル当たりの燃焼回数が２回と判断された場合も同様に、Ｓ１９で図１０（ｂ）に示すバルブタイミングに変更し、Ｓ２０で第２の４行程サイクル運転（図８）の制御を開始する。

【００５４】次に、本発明の第２の実施の形態について説明する。第２の実施の形態の構成を図１３に示す。第２の実施の形態の構成は第１実施の形態の構成を示す図１とほぼ同様であるが、第１の実施の形態に対して、吸気系に空気量を制御するスロットルバルブ２１、排気系に排気ガス浄化用の三元触媒２０、ＥＣＵ１にはスロットル制御部６がそれぞれ追加されているところが異なる。

【００５５】第２の実施形態では、第２の４行程サイクル運転時のサイクル当たり２回の燃焼のためのそれぞれの燃料噴射量を概略等しくするとともに、ガス交換後に気筒内に吸入された空気量に対する２回の燃焼用の燃料噴射量の合計が理論空燃比（ストイキ）となることを特徴とする。また要求トルクから計算される空燃比が理論空燃比よりもリッチになる場合には自己着火運転を禁止して、火花点火運転を行うことを特徴とする。

【００５６】図１４は、第２実施の形態における第２の

４行程サイクル中の筒内の成分割合を示す。第１の実施の形態（図９）では２回目の燃焼が終了した時点、すなわちガス交換前の筒内においても空気が存在しており、筒内は常にリーンになっている。これに対して第２実施の形態では、２回目の燃焼が終了した時点では筒内に余剰空気は存在せず、筒内は理論空燃比になっている。従って、排気系に設置した三元触媒２０が高効率で働くため、エンジンから排出されるエミッションを低減できる。

【００５７】また図１４に示すように、第２実施の形態では１回目の燃焼と２回目の燃焼の燃料量は概略一定としている。従って、１回目の燃焼と２回目の燃焼で得られるトルクは等しくなるため、音振性能がさらに改善され、運転性をより向上させることができる。

【００５８】第２実施の形態では筒内の燃料ガスの割合は概略一定となる。理論空燃比の空燃比を例えば１４．５とすると１回目の燃焼時の空燃比は２９となる。続く２回目の燃焼では燃料量が一定のため、ガスと燃料の割合すなわちＧ／Ｆは２９となるものの、空気量に対する比率すなわちＡ／Ｆは１４．５となる。このように第２実施の形態ではガス量に対する燃料量は一定のため、負荷の制御はスロットルバルブ２１により空気量を制御して行う。なお、圧縮自己着火運転時には、空燃比はリーンのため、空気量は多く、スロットルバルブにより発生するポンプ損失は少ない。

【００５９】図１５は、第２実施の形態の制御の流れを示すフローチャートである。第２実施の形態の制御の流れは第１実施の形態（図１２）とほぼ同様であるが、Ｓ１６でサイクル当たりの燃焼回数が２回と判断された後、Ｓ１９で第２の４行程サイクルに適したバルブタイミングに変更した後の制御が異なる。

【００６０】即ち、Ｓ１９に続くＳ３０で要求エンジン回転数Ｎと負荷Ｔを確認する。次いでＳ３１で要求負荷Ｔをもとに図１６のマップからスロットル開度ＴＶＯを求め、スロットル制御部６からスロットル２１に制御信号を送り、マップで求めたスロットル開度ＴＶＯにスロットル２１をセットする。

【００６１】次いでＳ３２で吸入空気量Ｑを検出する。次いでＳ３３でエンジン回転数Ｎ、吸入空気量Ｑをもとに燃料量Ｆを図１７のマップから算出する。このように制御することによって、第２の４行程サイクルにおける各４行程サイクル当たりの空燃比を理論空燃比とするとともに、各燃焼サイクルにおいてガスと燃料の比が約２９に制御できる。すなわち、所望のトルクを実現すると共に、よりリーンな空燃比で燃焼させることが可能となる。

【００６２】次に、本発明の第３の実施の形態について説明する。第３の実施の形態の構成を図１８に示す。第３の実施の形態の構成は第２実施の形態の構成（図１３）とほぼ同様であるが、第２実施の形態に対して吸気系に過給機２２が追加され、ＥＣＵ１に過給圧制御部７が追加されているところが異なる。

【００６３】第３実施の形態は、要求負荷Ｔに対して、スロットル開度ＴＶＯに加えて過給圧Ｐについても制御するところを特徴とする。即ち要求負荷Ｔが大きく、スロットルが全開となった場合においても空気量が不足し、サイクル当たりの筒内吸入空気量に対する２回の燃焼用の燃料噴射量の合計が理論空燃比よりリッチになる場合には過給圧Ｐを増加させ、空気量を増やすことによって空燃比を理論空燃比に制御する。また、過給圧Ｐを増加させた場合には既燃ガスと新気のガス交換の効率が向上する。このため、筒内に残る残留ガスが低減し、筒内に入る新気の割合も増加するため、更に燃料量を増加させることができ、より大きな要求負荷に対しても自己着火燃焼領域を拡大させることができる。

【００６４】図１９に過給圧Ｐを増大させた場合における自己着火成立範囲を示す。スロットル開度（ＴＶＯ）制御に対して、過給圧制御を行うことによって、自己着火運転範囲を第２実施形態よりさらに高負荷側に拡大することができる。

【００６５】図２０は、第３実施の形態の制御の流れを示すフローチャートである。第３実施の形態の制御の流れは第２実施の形態を示す図１５とほぼ同様であるが、Ｓ１９のバルブタイミング変更後の動作が異なる。

【００６６】即ち図２０において、Ｓ１９に続いて、Ｓ５０で要求エンジン回転数Ｎ、要求負荷Ｔを確認する。Ｓ５１でエンジン回転数Ｎ、負荷Ｔをもとに図１９のマップからスロットル開度ＴＶＯ制御を行う領域か、過給圧Ｐ制御を行う領域かを判断する。過給圧Ｐ制御を行う場合はＳ５２で要求負荷Ｔをもとに過給圧制御を行う。これは、図２１に示すような、各エンジン回転毎に用意された要求負荷Ｔに対する過給圧Ｐのマップを用いて行う。図２１から明らかなように、要求負荷が一定値までは過給圧は小さい一定値、或いは０であるが、要求負荷Ｔが一定値を超えると、要求負荷の増分に比例して必要な過給圧の増分が大きくなる。

【００６７】Ｓ５１でスロットル開度ＴＶＯ制御と判断された場合にはＳ５３で要求負荷Ｔに基づいてスロットル開度ＴＶＯを制御する。次いでＳ５４で吸入空気量Ｑを検出し、Ｓ５５でエンジン回転数Ｎと吸入空気量Ｑより燃料噴射量Ｆを算出する。

【００６８】このようにスロットル開度ＴＶＯと過給圧Ｐを制御することによって、自己着火運転領域をさらに高負荷側に拡大することができる。

【００６９】次に、本発明の第４の実施の形態について説明する。第４の実施の形態の構成は、図１に示した第１実施の形態の構成と同じである。

【００７０】第４実施の形態は、通常の４行程サイクルによる火花点火燃焼、通常の４行程サイクルによる圧縮自己着火燃焼、及び６行程サイクルによる圧縮自己着火燃焼を運転状態に応じて切り換え可能であり、６行程サイクル中にガス交換は１回とし、燃焼回数は３回とすることを特徴とする。

【００７１】図２２に第４実施の形態における６行程サイクルを示す。この６行程サイクルは、吸気圧縮行程→膨張行程→圧縮行程→膨張行程→圧縮行程→膨張排気行程からなる。そして６行程サイクル中ガス交換は１回である。また、燃焼回数は、６行程サイクル中に２回の膨張行程と１回の排気膨張行程との合計３回となり、すなわちサイクルを構成する行程数の１／２である。

【００７２】図２３（ｂ）に第４実施の形態のバルブタイミング（バルブリフト）を示す。同図（ａ）に示す燃焼回数が２回の第１実施の形態にくらべても燃焼回数に対するガス交換回数が少ないことがわかる。このようにカムプロフィールの異なるカムを切り替えることによって、またはクランク軸回転数からカム軸回転数への減速比を変えることによって、燃焼サイクルを４行程サイクルから６行程サイクルに変更することができる。またバルブタイミングの変更は電磁駆動バルブ等を用いても良い。

【００７３】また、本実施の形態では、燃焼回数３回に対して、ガス交換が１回と回数が少ないため、未燃ガスの排出を低減することができる。また、１回のガス交換に続いて燃焼が３回連続するため、２回目、３回目の燃焼では既燃ガスによって筒内の圧力、温度が上昇している。このため、燃料が燃えやすくなるため、燃焼過程で発生する未燃ガスを低減することができる。これら２つの効果によって、未燃ガスを低減できる。

【００７４】図２４に第４実施の形態の筒内成分割合を模式的に示す。自己着火燃焼では燃料が少ないリーンな状態において燃焼させることができるため、燃焼回数が３回連続しても空気は十分存在する。

【００７５】第４実施の形態の制御の流れは、図１２に示した第１実施の形態とほぼ同様であるが、Ｓ１６の燃焼回数判断が１回又は３回を判断するものに変更されるとともに、３回と判断されたときにＳ１９へ移ること、Ｓ２０で第２の４行程サイクル制御開始に替えて６行程サイクル制御開始となること、及び使用するカム又は電磁バルブの制御タイミングのみが異なる。

【００７６】尚、本実施の形態では６行程サイクルを例に説明したが、サイクル当たりの工程数が８行程以上の場合においても同様のことが考えられる。その場合には、膨張排気行程の前に更に膨張（燃焼）行程および圧縮行程が複数回、繰り返されることになる。

【００７７】次に、本発明の第５の実施の形態について説明する。第５の実施の形態の構成は、図１３に示した第２実施の形態の構成と同じである。

【００７８】第５実施の形態では、第４実施の形態に対して、１回のガス交換に対応する複数回の燃焼における各燃焼の燃料量を概略等しくし、更にガス交換後の吸気量に対する複数回の燃焼用の燃料量の合計を理論空燃比にすることを特徴とする。

【００７９】図２５に第５実施の形態の筒内成分割合を模式的に示す。第５実施の形態では３回の燃焼の燃料量は等しくなっており、図２５（ａ）の吸気圧縮行程で気筒内に吸入された空気量に対する３回分の燃焼用の燃料量の合計値が理論空燃比となっている。これは、言い換えれば、図２５（ｅ）の圧縮行程における３回目の燃焼時の空燃比は理論空燃比になっている。従って、図２５（ｆ）の膨張排気行程によるガス交換時には余剰の空気は存在せず、すべて既燃ガスとなる。

【００８０】理論空燃比を１４．５とすると１回目の燃焼ではガスと燃料の割合（Ｇ／Ｆ）は約４３．５となっている。このとき、空燃比（Ａ／Ｆ）も約４３．５である。２回目の燃焼ではＧ／Ｆは約４３．５となっており、Ａ／Ｆは約２９となる。３回目の燃焼ではＧ／Ｆは約４３．５となっており、Ａ／Ｆは約１４．５である。

【００８１】このように、各燃焼でＧ／Ｆが一定となっているため、それぞれの燃焼から得られるトルクは一定となり、運転性が損なわれることを防げる。また、ガス交換前の燃焼時の空燃比が理論空燃比となっているため、排気系に設置された三元触媒が高効率で働くためエンジンから排出されるエミッションを低減できる。

【００８２】第５実施の形態の制御の流れは、図１５に示した第２実施の形態とほぼ同様であるが、Ｓ１６の燃焼回数判断が１回又は３回を判断するものに変更されるとともに、３回と判断されたときにＳ１９へ移ること、及び使用するカム又は電磁バルブの制御タイミングのみが異なる。

【００８３】尚、本実施の形態では６行程サイクルを例に説明したが、サイクル当たりの行程数が８行程数以上の場合においても同様のことが考えられる。その場合には、膨張排気行程の前に更に膨張行程および圧縮行程が複数回、繰り返されることになる。また、その場合においても、ガス交換後の吸気量に対する複数回の燃焼用の燃料量の合計が理論空燃比となるように、言い換えればガス交換前の空燃比は理論空燃比となるように燃料量を制御する。

【００８４】さらに、発電機駆動用等の運転条件が比較的狭い範囲に限定される内燃機関においては、通常の４行程サイクル運転を行わず、第４及び第５実施形態の６行程サイクルまたは６以上の行程数を有するサイクルの運転のみにより稼働させ、燃料消費率の削減及び排気の浄化を高レベルで実現することができる。

【図面の簡単な説明】

【図１】本発明に係る内燃機関の燃焼制御装置の第１実施形態の構成図である。

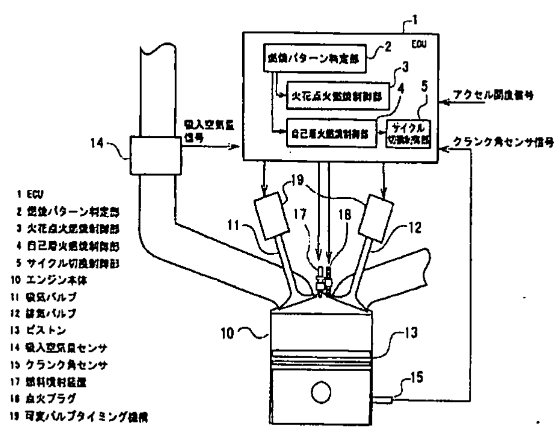
【図２】運転条件に対する燃焼パターンを説明する図である。

【図３】自己着火燃焼成立範囲を説明する図である。

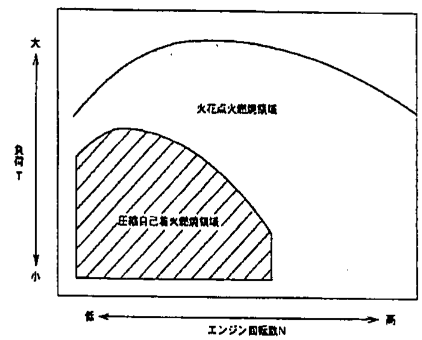
【図４】第１の４行程サイクル（燃焼回数１回の４行程サイクル）を説明する図である。
【図５】第１の４行程サイクルの自己着火燃焼成立範囲を説明する図である。
【図６】２行程サイクルを説明する図である。
【図７】２行程サイクルの自己着火燃焼成立範囲を説明する図である。
【図８】第２の４行程サイクル（燃焼回数２回の４行程サイクル）を説明する図である。
【図９】第２の４行程サイクルの筒内成分割合を説明する図である。
【図１０】バルブタイミングを説明する図である。
【図１１】第２の４行程サイクルの自己着火燃焼成立範囲を説明する図である。
【図１２】第１実施の形態の動作を説明するフローチャートである。
【図１３】第２実施の形態の構成図である。
【図１４】第２実施の形態の筒内成分割合を説明する図である。
【図１５】第２実施の形態の動作を説明するフローチャートである。
【図１６】要求負荷Ｔに対するスロットル開度ＴＶＯを説明する図である。
【図１７】回転当たりの吸気量Ｑ／Ｎに対する燃料噴射量Ｆを説明する図である。
【図１８】第３実施の形態の構成図である。
【図１９】第３実施の形態の自己着火燃焼成立範囲を説明する図である。
【図２０】第３実施の形態の動作を説明するフローチャートである。

【図２１】要求負荷に対する過給圧を説明する図である。
【図２２】第４実施の形態の６行程サイクルを説明する図である。
【図２３】第４実施の形態のバルブタイミングを説明する図である。
【図２４】第４実施の形態の筒内成分割合を説明する図である。
【図２５】第５実施の形態の筒内成分割合を説明する図である。
【符号の説明】
１　ＥＣＵ
２　燃焼パターン判定部
３　火花点火燃焼制御部
４　自己着火燃焼制御部
５　サイクル切換制御部
１０　エンジン本体
１１　吸気バルブ
１２　排気バルブ
１３　ピストン
１４　吸入空気量センサ
１５　クランク角センサ
１７　燃料噴射装置
１８　点火プラグ
１９　可変バルブタイミング機構
２０　三元触媒
２１　スロットルバルブ
２２　過給機

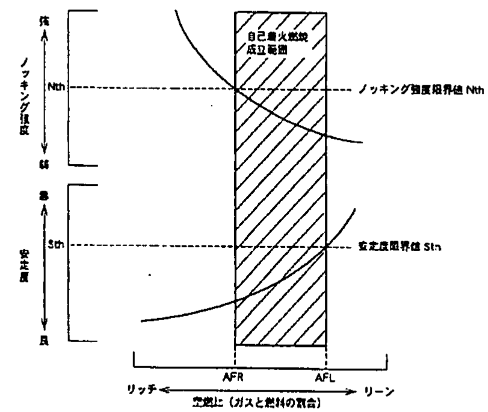
【図１】



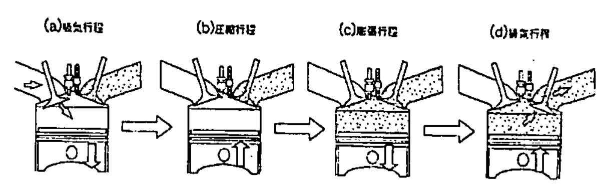
【図２】



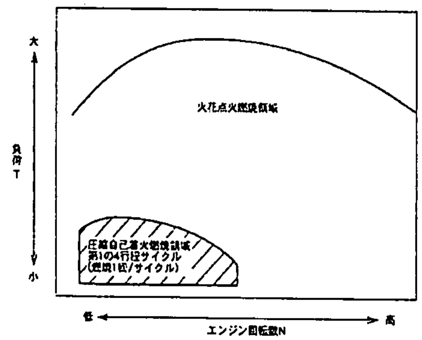
【図３】



【図４】



【図５】



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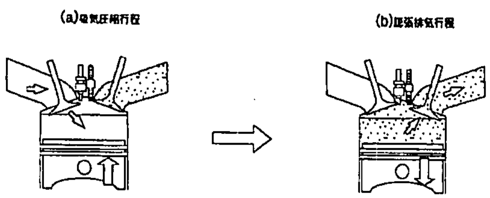

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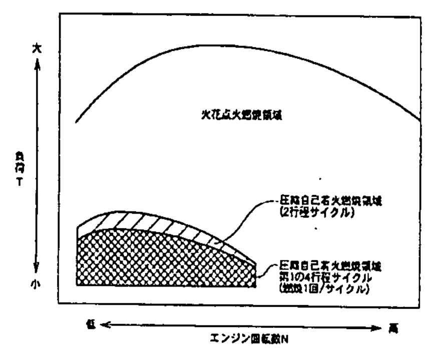

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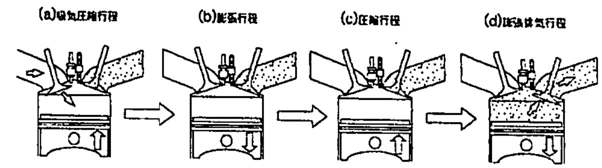

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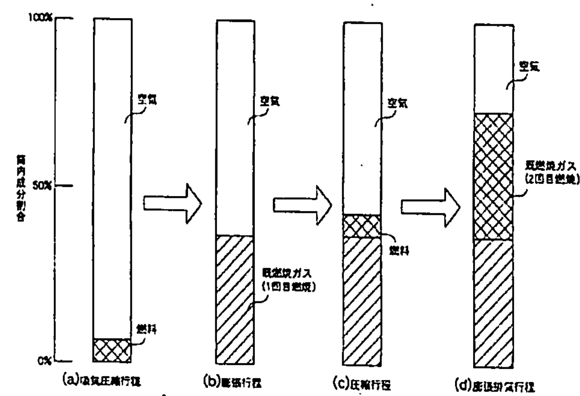
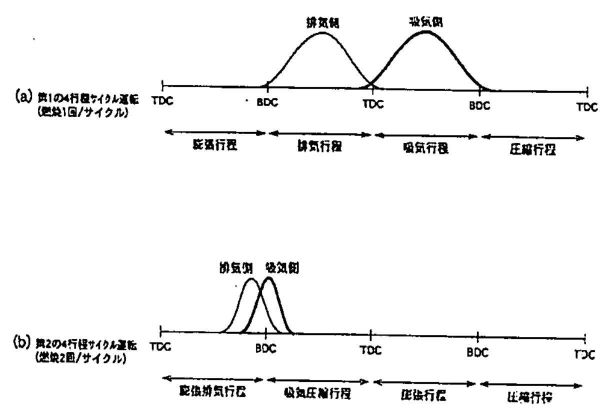
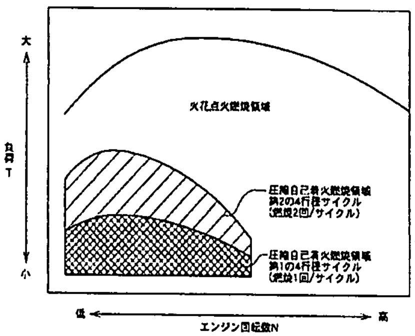


【図１０】



【図１１】



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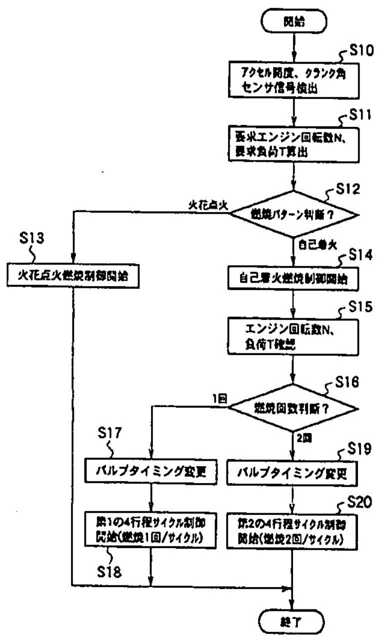

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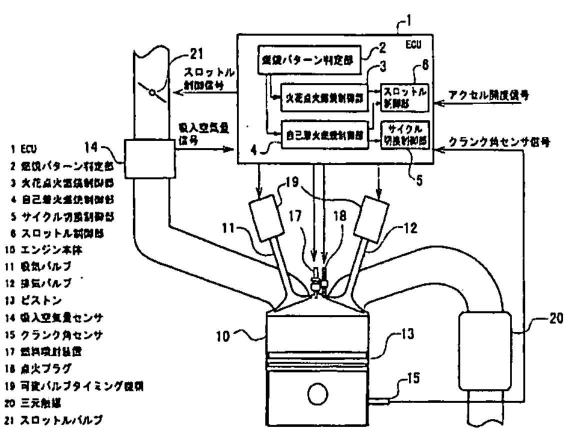

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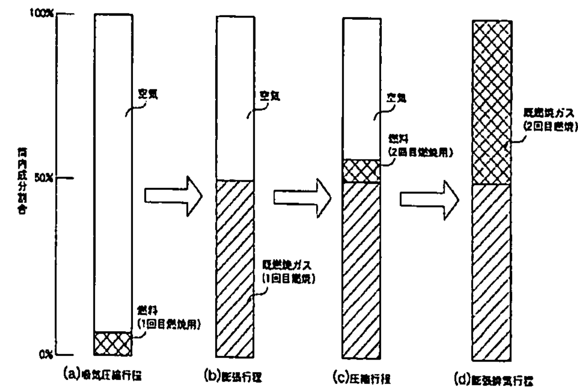

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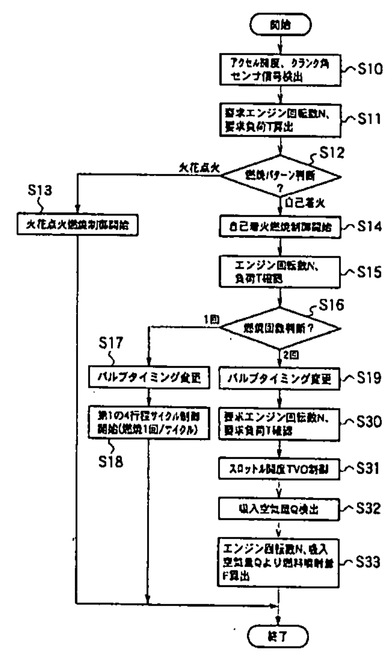

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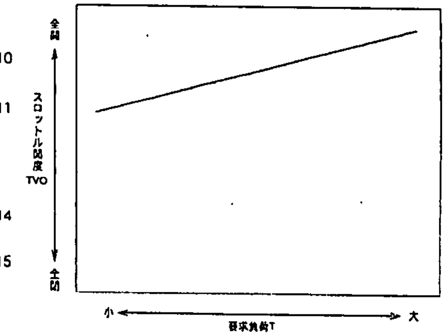

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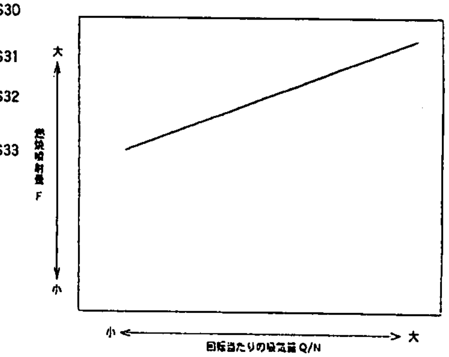

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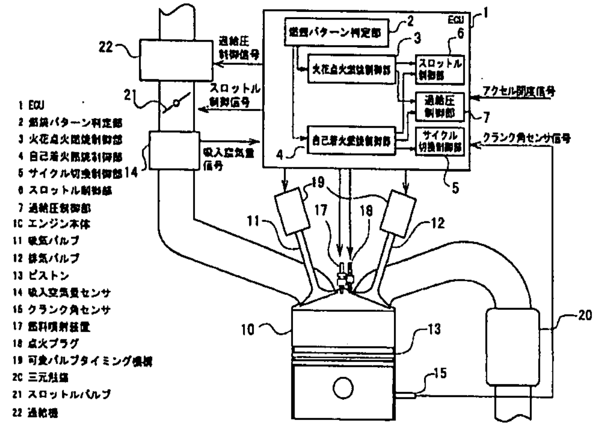
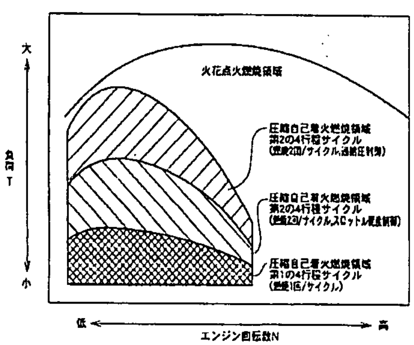
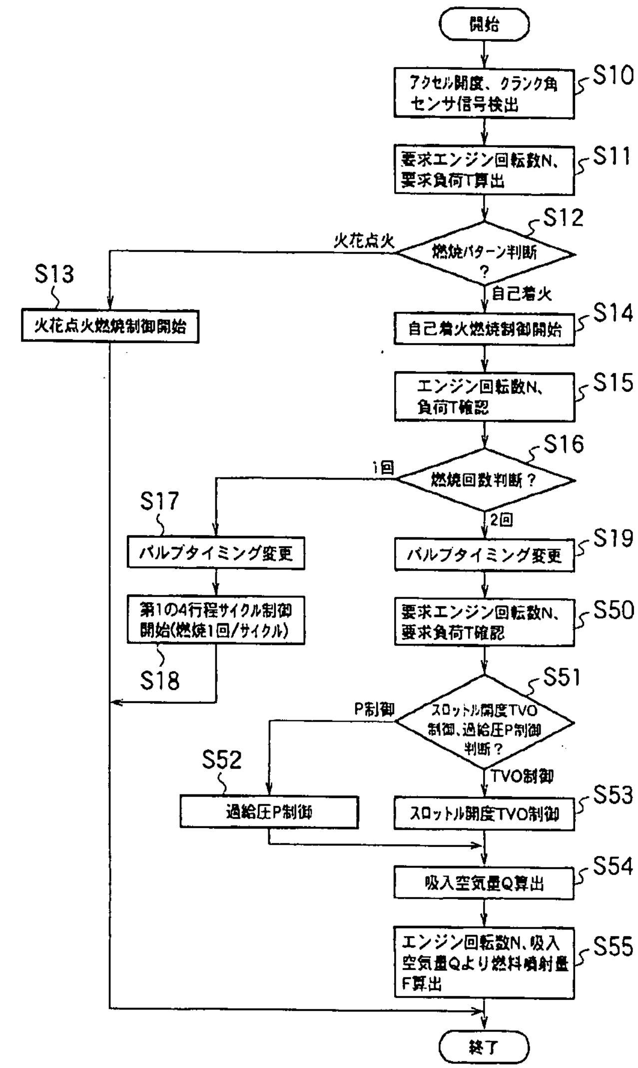

ECU
燃焼パターン判定部
火花点火燃焼制御部
自己着火燃焼制御部
スロットル制御部
過給圧制御部
サイクル切換制御部
過給圧制御信号
スロットル制御信号
吸入空気量信号
アクセル開度信号
クランク角センサ信号
1 ECU
2 燃焼パターン判定部
3 火花点火燃焼制御部
4 自己着火燃焼制御部
5 サイクル切換制御部
6 スロットル制御部
7 過給圧制御部
10 エンジン本体
11 吸気バルブ
12 排気バルブ
13 ピストン
14 吸入空気量センサ
15 クランク角センサ
17 燃料噴射装置
18 点火プラグ
19 可変バルブタイミング機構
20 三元触媒
21 スロットルバルブ
22 過給機

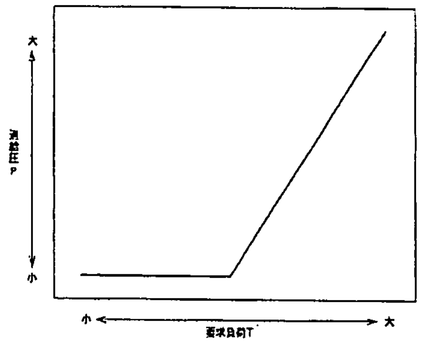
【図19】


大
負荷T
小
火花点火燃焼領域
圧縮自己着火燃焼領域
第2の4行程サイクル
(燃焼2回/サイクル,過給圧制御)
圧縮自己着火燃焼領域
第2の4行程サイクル
(燃焼2回/サイクル,スロットル開度制御)
圧縮自己着火燃焼領域
第1の4行程サイクル
(燃焼1回/サイクル)
低
エンジン回転数N
高

【図20】


開始
アクセル開度、クランク角センサ信号検出
S10
要求エンジン回転数N、要求負荷T算出
S11
燃焼パターン判断?
S12
火花点火
自己着火
S13
火花点火燃焼制御開始
自己着火燃焼制御開始
S14
エンジン回転数N、負荷T確認
S15
燃焼回数判断?
S16
1回
2回
S17
バルブタイミング変更
第1の4行程サイクル制御開始(燃焼1回/サイクル)
S18
バルブタイミング変更
S19
要求エンジン回転数N、要求負荷T確認
S50
スロットル開度TVO制御、過給圧P制御判断?
S51
P制御
TVO制御
S52
過給圧P制御
スロットル開度TVO制御
S53
吸入空気量Q算出
S54
エンジン回転数N、吸入空気量Qより燃料噴射量F算出
S55
終了

【図２１】



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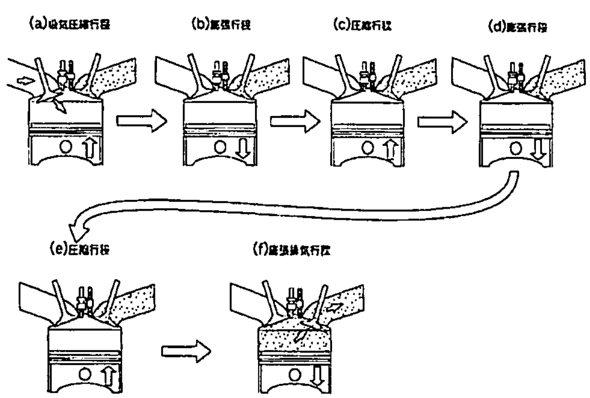

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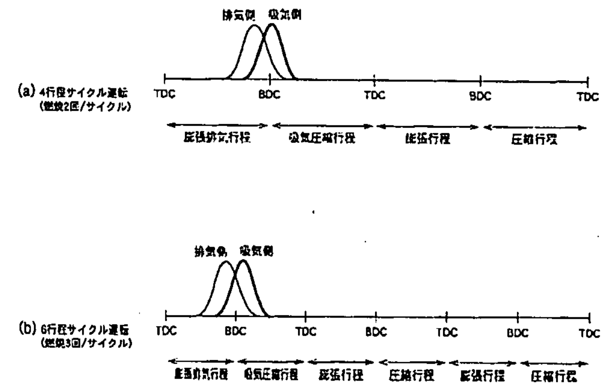

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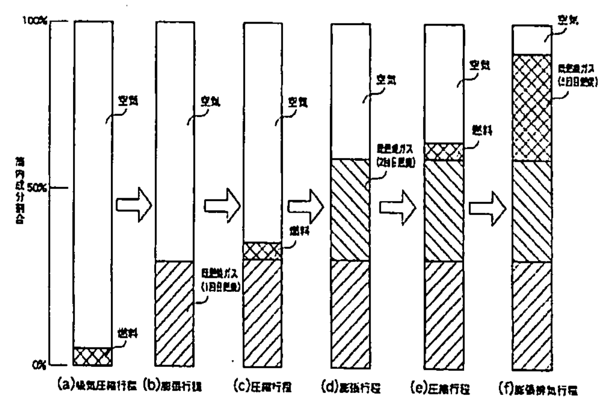

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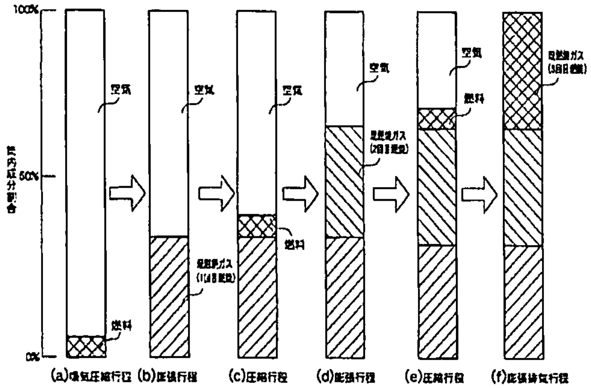

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3G023 AA02 AA03 AA18 AB06 AC04
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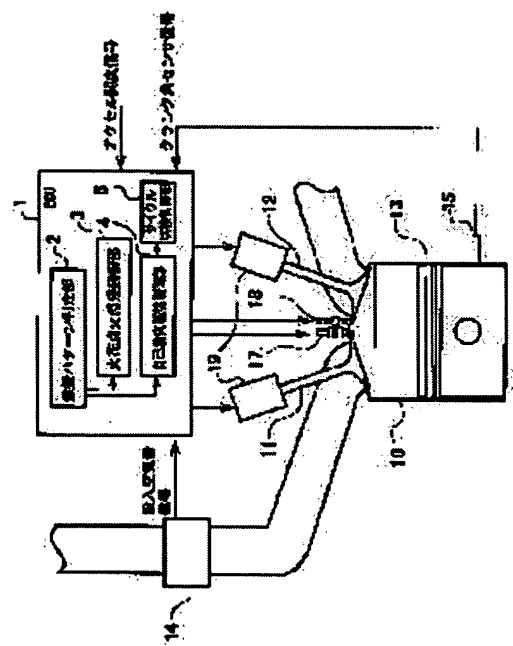
TANIYAMA TAKESHI
SAKAKIDA AKIHIRO

(54) COMBUSTION CONTROL DEVICE FOR INTERNAL COMBUSTION ENGINE

(57)Abstract:



PROBLEM TO BE SOLVED: To provide a combustion control device for an internal combustion engine capable of expanding an operating range by compressed self-ignition combustion to a high load side and a low load side.

SOLUTION: An ECU 1 calculates request load T and engine speed N based on an accelerator opening signal and a crank angle sensor signal. Based on this calculated result, whether a combustion pattern is spark ignition combustion or self-ignition combustion is decided by a combustion pattern deciding part 2. When the combustion pattern is decided as self-ignition combustion, a self- ignition combustion control part 4 selects a first four-stroke cycle operation constituted of intake stroke, compression stroke, expansion stroke and exhaust stroke and a second four-stroke cycle operation which is constituted of intake compression stroke, expansion stroke, compression stroke and expansion exhaust stroke and performs combustion two times during a four-stroke cycle. A cycle switching control part 5 controls a variable valve timing

mechanism 19 and realizes intake/exhaust valve timing for the first or second four-stroke cycle.

LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the combustion control system of the internal combustion engine which made adjustable composition of the distance in 1 cycle of compressed self-ignition combustion in the internal combustion engine which can switch jump-spark-ignition combustion and compressed self-ignition combustion according to a service condition.
[0002]
[Description of the Prior Art] In order to improve the thermal efficiency of a gasoline engine, while reducing a pumping loss by RIN-izing a gaseous mixture, the technique of enlarging the ratio of specific beat of working medium, and improving a theoretical thermal efficiency is known. However, with the conventional jump-spark-ignition engine, if an air-fuel ratio is made into RIN, a combustion period will delay and combustion stability will get worse. For this reason, there is a limitation in RIN-ization of an air-fuel ratio.
[0003] It considers as the conventional technology which RIN-izes an air-fuel ratio, avoiding aggravation of such combustion stability, and the cycle engine which premixing compressed self-ignition combustion is made to cause as it is in JP,7-71279,A is indicated like 2 line. In premixing compressed self-ignition combustion, since a combustion reaction occurs from two or more positions of a combustion chamber, when an air-fuel ratio RIN-izes, the combustion stabilized also in the RIN air-fuel ratio is attained, without a combustion period delaying compared with jump spark ignition. Moreover, since an air-fuel ratio is RIN, combustion temperature falls, and NOx can also be reduced sharply.
[0004] Moreover, the cycle operation engine of port injection is indicated by JP,10-252511,A like 6 line as 2nd conventional example. In the 2nd conventional example, when incomplete combustion happens after engine starting, it has switched to the usual like [6 line] cycle operation by which the pair of cycle operation to a compression stroke and expansion (combustion) distance of about four lines is repeated twice continuously.
[0005] Furthermore, the cycle operation engine of the direct injection formula which equipped JP,5-240049,A with the air chamber which can be open for free passage to a combustion chamber as 3rd conventional example by the air chamber valve which can be opened and closed is indicated like 6 line. the 3rd conventional example -- like the 1st intake stroke, the 1st compression stroke, the 2nd intake stroke, the 2nd compression stroke, expansion (combustion) distance, and an exhaust air line -- from -- becoming like [6 line] cycle operation is shown
[0006] The 1st compression stroke of a cycle of about six lines is for storing in the air chamber equipped with the air chamber valve which can open and close this air compressed into an elevated temperature and high pressure temporarily. Combustion is promoted by replacing the air of a combustion chamber with the 2nd intake stroke, injecting and burning gas oil in the combustion chamber which became an elevated temperature and high pressure by the 2nd compression stroke, making the high-pressure air stored from the air chamber into the expansion stroke blow off, and stirring a combustion chamber.

[0007]
[Problem(s) to be Solved by the Invention] However, in the 1st conventional example, since [usual] about two lines was considered as cycle engine composition, there are no inhalation-of-air bulb and exhaust air bulb which control a gas exchange, the blow by of unburnt glow gas occurred, and mpg was getting worse. Moreover, since the gas exchange of about two lines is 1 time into the cycle, emission may get worse by eccrisis unburnt [HC]. Moreover, since an expansion stroke consisted of the need of performing a gas exchange like the expansion exhaust air line which exhausts in the second half and work was not able to be enough taken out from expansion of combustion gas, there was a trouble that heavy load operation was difficult.
[0008] On the other hand, self-ignition combustion is strongly influenced of an air-fuel ratio. For example, when heavy load operation is considered and an air-fuel ratio is made deep, the fuel quantity which starts a combustion reaction increases, and combustion becomes intense and causes knocking. Therefore, in order to suppress knocking below on predetermined level, fuel quantity sendable in a cylinder is restricted. For this reason, the trouble [number of times / of combustion] that one usual operation according to the self-ignition combustion by the heavy load with a cycle engine about four lines was difficult was in two rotations.
[0009] Moreover, although about four lines can be switched to a cycle about six lines from a cycle, since fuel injection is port injection, in the combustion cycle which is the 2nd time, new fuel is not sendable [with the 2nd conventional technology]. Therefore, the fuel of non-** will realize 2nd combustion only at the time of incomplete combustion generating. For this reason, there was a trouble that it was difficult to raise a load.
[0010] moreover, with the 3rd conventional technology, since the piston downward distance in a cycle had turned into the 1st and 2nd intake strokes and an expansion stroke, there was a trouble of about six lines that it was difficult for the number of times of combustion to be able to become only 1 time of an expansion stroke, to be fully able to take out from combustion gas to work, and to raise a load
[0011] Furthermore, although a pressure and temperature needed to be raised and high compression ratio-ization was needed in the compression stroke in order to form compressed self-ignition combustion, when compatibility with the full-load-running field where an output is demanded was considered, there was the need of lowering a compression ratio to some extent for suppression of knocking. However, when a compression ratio was lowered, there was a trouble that the load range in which self-ignition combustion is materialized became narrow.
[0012] this invention is what took the example by this trouble, and the purpose is offering the combustion control system of an internal combustion engine which can expand the operating range by compressed self-ignition combustion to a heavy load and low load side, avoiding knocking and combustion instability. Moreover, by lessening the number of times of a gas exchange to the number of times of combustion, the purpose of this invention improves mpg and emission and thermal efficiency is to offer a clean high internal combustion engine.
[0013]
[Means for Solving the Problem] In order that invention according to claim 1 may solve the above-mentioned technical problem, it has in a cylinder the fuel direct injection equipment which injects direct fuel, and the good change valve gear which can change the opening-and-closing stage of an induction-exhaust valve. According to a service condition, it sets to the internal combustion engine which can switch compressed self-ignition combustion and jump-spark-ignition combustion. like an intake stroke, a compression stroke, an expansion stroke, and an exhaust air line -- from -- with the 1st becoming like [4 line] cycle operation Let the 2nd thing to which an inhalation-of-air compression stroke, an expansion stroke, a compression stroke, and an expansion exhaust air line perform two combustion of about four lines into a cycle in a shell and for which the switch of cycle operation of about four lines was enabled at the time of compressed self-ignition combustion be a summary.
[0014] Invention according to claim 2 makes it a summary for the two aforementioned sum totals of the fuel oil consumption for combustion to be [of about four lines] the fuel oil consumption according to target torque of the above 2nd in the combustion control system of an internal combustion engine

according to claim 1 at the time of cycle operation in order to solve the above-mentioned technical problem.
[0015] In order that invention according to claim 3 may solve the above-mentioned technical problem, in the combustion control system of an internal combustion engine according to claim 1 or 2, the two aforementioned sum totals of the fuel oil consumption for combustion to the air content of the above 2nd inhaled in the cylinder by the end of the aforementioned inhalation-of-air compression stroke at the time of cycle operation make a summary the theoretical air fuel ratio and the bird clapper of about four lines.
[0016] In order that invention according to claim 4 may solve the above-mentioned technical problem, in the combustion control system of an internal combustion engine according to claim 1 or 2, the two aforementioned sum totals of the fuel oil consumption for combustion to the air content of the above 2nd inhaled in the cylinder by the end of the aforementioned inhalation-of-air compression stroke at the time of cycle operation make a summary the stratification air-fuel ratio and bird clapper of about four lines.
[0017] Invention according to claim 5 is set to the combustion control system of the internal combustion engine of a claim 1 or a claim 4 given in any 1 term in order to solve the above-mentioned technical problem. When torque is further required rather than the amount from which the two aforementioned sum totals of the fuel oil consumption for combustion to the air content of the above 2nd inhaled in the cylinder by the end of the aforementioned inhalation-of-air compression stroke at the time of cycle operation of about four lines serve as theoretical air fuel ratio, Let it be a summary to switch to the usual jump-spark-ignition combustion from compressed self-ignition combustion.
[0018] In order that invention according to claim 6 may solve the above-mentioned technical problem, in the combustion control system of the internal combustion engine of a claim 1 or a claim 5 given in any 1 term, it is further equipped with a supercharge means to supercharge inhalation of air, and the charge pressure control means which control the charge pressure of this supercharge means, and makes a summary the thing of about four lines of the above 2nd for which the aforementioned charge pressure control means control charge pressure so that the air-fuel ratio in a cylinder turns into theoretical air fuel ratio at the time of cycle operation.
[0019] In order that invention according to claim 7 may solve the above-mentioned technical problem, it has in a cylinder the fuel direct injection equipment which injects direct fuel, and the good change valve gear which can change the opening-and-closing stage of an induction-exhaust valve. In the internal combustion engine which performs operation which has the distance of six or more lines per 1 cycle about, it is the combustion control system of the internal combustion engine which makes it a summary to make opening and closing of the pumping bulb for performing a gas exchange into the aforementioned cycle into 1 time, and to set the number of times of combustion to one half of the numbers of stroke per aforementioned cycle.
[0020] Invention according to claim 8 makes a summary the thing of about six lines for which the sum total of the fuel oil consumption per [to the air content in a cylinder after a gas exchange] 1 cycle was made into theoretical air fuel ratio at the time of operation more than a cycle by compressed self-ignition combustion in the combustion control system of an internal combustion engine according to claim 7 in order to solve the above-mentioned technical problem.
[0021] Invention according to claim 9 makes a summary the thing of about six lines for which the sum total of the fuel oil consumption per [to the air content in a cylinder after a gas exchange] 1 cycle was made into the stratification air-fuel ratio at the time of operation more than a cycle by compressed self-ignition combustion in the combustion control system of an internal combustion engine according to claim 7 in order to solve the above-mentioned technical problem.
[0022]
[Effect of the Invention] According to this invention according to claim 1, have in a cylinder the fuel direct injection equipment which injects direct fuel, and the good change valve gear which can change the opening-and-closing stage of an induction-exhaust valve, and it sets according to a service condition to the internal combustion engine which can switch compressed self-ignition combustion and jump-spark-ignition combustion. like an intake stroke, a compression stroke, an expansion stroke, and an exhaust air line -- from -- with the 1st becoming like [4 line] cycle operation Since the switch of the

2nd like [4 line] cycle operation to which an inhalation-of-air compression stroke, an expansion stroke, a compression stroke, and an expansion exhaust air line perform two combustion of about four lines into a cycle in a shell was enabled at the time of compressed self-ignition combustion As opposed to the 2nd like [4 line] cycle engine usual [about four lines] in the field of cycle operation Since the number of times of combustion per engine rotation can be increased to double precision, it is attained more, compressed self-ignition operation, i.e., efficient and clean operation, in a heavy load region, and mpg and emission can be improved. Moreover, since the usual number of times [as opposed to / as opposed to / a cycle engine / about two lines] the number of times of combustion / of a gas exchange can be reduced to one half, mpg and emission are improvable.

[0023] according to this invention according to claim 2 -- an effect of the invention according to claim 1 -- in addition, at the time of cycle operation, since the sum total of the fuel oil consumption for combustion of the two aforementioned time considered as the fuel oil consumption according to target torque of the above 2nd, it can obtain the output torque as target torque, and can offer the good internal combustion engine of operability of about four lines

[0024] According to this invention according to claim 3, it adds to an effect of the invention according to claim 1 or 2. Since it was made for the two aforementioned sum totals of the fuel oil consumption for combustion to the air content of the above 2nd inhaled in the cylinder by the end of the aforementioned inhalation-of-air compression stroke at the time of cycle operation of about four lines to serve as theoretical air fuel ratio Efficient operation is attained, while the air-fuel ratio of the gas discharged from an internal combustion engine also always turns into theoretical air fuel ratio, making the three way component catalyst which purifies exhaust air act efficiently and defecating exhaust air extremely.

[0025] according to this invention according to claim 4 -- an effect of the invention according to claim 1 or 2 -- in addition, since it was made for the sum total of the fuel oil consumption for combustion of the two aforementioned time to the air content of the above 2nd inhaled in the cylinder by the end of the aforementioned inhalation-of-air compression stroke at the time of cycle operation of about four lines to serve as a stratification air-fuel ratio, mpg is further improvable

[0026] According to this invention according to claim 5, in addition to the effect of the invention of a claim 1 or a claim 4 given in any 1 term, it sets to the combustion control system of an internal combustion engine. When torque is further required rather than the amount from which the two aforementioned sum totals of the fuel oil consumption for combustion to the air content of the above 2nd inhaled in the cylinder by the end of the aforementioned inhalation-of-air compression stroke at the time of cycle operation of about four lines serve as theoretical air fuel ratio, By switching to the usual jump-spark-ignition combustion from compressed self-ignition combustion, the combustion gas discharged from an internal combustion engine becomes more rich than SUTOIKI, and it can prevent emission getting worse without the ability using a three way component catalyst effectively.

[0027] According to this invention according to claim 6, to the effect of the invention of a claim 1 or a claim 5 given in any 1 term In addition, a supercharge means to supercharge inhalation of air, Since the aforementioned charge pressure control means controlled charge pressure so that it had further the charge pressure control means which control the charge pressure of this supercharge means and the air-fuel ratio in a cylinder turned into theoretical air fuel ratio at the time of 4 distance cycle operation of the above 2nd It is attained more, compressed self-ignition operation, i.e., efficient and clean operation, in a heavy load region, and mpg and emission can be improved. Moreover, efficient operation is attained, without being able to utilize now the very high three way component catalyst of the rate of purification of emission, and getting worse emission, since the air-fuel ratio of the gas discharged from an internal combustion engine always turns into theoretical air fuel ratio.

[0028] In the internal combustion engine which performs operation which according to this invention according to claim 7 is equipped with the fuel direct injection equipment which injects direct fuel, and the good change valve gear which can change the opening-and-closing stage of an induction-exhaust valve in a cylinder, and has the distance of six or more lines per 1 cycle about By making opening and closing of the pumping bulb for performing a gas exchange into 1 time, and setting the number of times of combustion to one half of the numbers of stroke per aforementioned cycle into the aforementioned

cycle Since the number of times of combustion per internal combustion engine rotation can be increased to double precision to the usual four-cycle internal combustion engine, it is attained more, compressed self-ignition operation, i.e., efficient and clean operation, in a heavy load region, and mpg and emission can be improved. Moreover, since the number of times of a gas exchange per cycle is 1 time, it can improve sharply the emission discharged from an internal combustion engine.
[0029] According to this invention according to claim 8, it adds to an effect of the invention according to claim 7. About six lines by compressed self-ignition combustion by having made the sum total of the fuel oil consumption per [to the air content in a cylinder after a gas exchange] 1 cycle into theoretical air fuel ratio at the time of operation more than a cycle Efficient operation of the air-fuel ratio of the gas discharged by gas exchange process from an internal combustion engine is attained without being able to utilize now the very high three way component catalyst of the rate of purification of emission, and getting worse emission, since it always becomes theoretical air fuel ratio.
[0030] according to this invention according to claim 9 -- an effect of the invention according to claim 7 -- in addition, mpg is further improvable by having made the sum total of the fuel oil consumption per [to the air content in a cylinder after a gas exchange] 1 cycle into the stratification air-fuel ratio by compressed self-ignition combustion at the time of operation more than 6 distance cycle
[0031]
[Embodiments of the Invention] Hereafter, the gestalt of operation of this invention is explained based on a drawing. Drawing 1 is the system configuration view which applied the combustion control system of the internal combustion engine concerning this invention to the gasoline engine and in which showing the 1st composition of the gestalt of operation.
[0032] In this operation gestalt, compressed self-ignition combustion and jump-spark-ignition combustion can be switched according to a service condition. further -- compressed self-ignition combustion -- setting -- like an intake stroke, a compression stroke, an expansion stroke, and an exhaust air line -- from -- like the 1st becoming like [4 line] cycle operation (usual like [4 line] cycle), an inhalation-of-air compression stroke and an expansion stroke, compression stroke, and expansion exhaust air line -- from -- the 2nd thing which becomes and performs two combustion of about four lines into a cycle and for which the switch of cycle operation is enabled in about four lines is the feature
[0033] The engine 10 in drawing is equipped with the inhalation-of-air bulb 11, the exhaust air bulb 12, a piston 13, the crank angle sensor 15, a fuel injection equipment 17, an ignition plug 18, and the adjustable valve timing mechanism 19, and is constituted. The inhalation-of-air system has the inhalation-of-air air-content sensor 14.
[0034] The electronic control (it abbreviates to ECU hereafter) 1 which controls this engine 10 While controlling the combustion pattern judging section 2 which judges whether it operates according to a service condition by which combustion system of compressed self-ignition combustion and jump-spark-ignition combustion, the jump-spark-ignition combustion-control section 3 at the time of jump-spark-ignition combustion operation which carries out combustion parameter control, and the combustion-control parameter at the time of compressed self-ignition combustion operation Compressed self-ignition combustion operation so that it may become [1st / 2nd / whether about four lines is performed by cycle operation or about four lines is performed by cycle operation, and] the 1st or 2nd like [4 line] cycle operation according to the judgment of the self-ignition combustion-control section 4 to judge and the self-ignition combustion-control section 4 The opening-and-closing stage of an induction-exhaust valve is changed, or it has the cycle change control section 5 which changes fuel oil consumption and fuel-injection timing.
[0035] In addition, although the component of ECU1, the combustion pattern judging section 2, the jump-spark-ignition combustion-control section 3, the self-ignition combustion-control section 4, and the cycle change control section 5 can also be constituted from a hard-wired logical circuit, they are realized as a program of a microcomputer with the gestalt of this operation.
[0036] Moreover, based on the inhalation air-content signal which the inhalation air-content sensor 14 detected, the engine speed signal which the crank angle sensor 15 detected, and the accelerator opening signal (load) which the accelerator opening sensor (not shown) detected, ECU1 judges a service

condition and computes fuel oil consumption and ignition timing. And based on this calculation result, a signal is sent to a fuel injection equipment 17 and an ignition plug 18.

[0037] Moreover, in compressed self-ignition combustion, according to a service condition, a cycle, in case [of the 2nd] it switches the cycle of about four lines and the number of times of combustion per cycle is changed, while sending a signal to the adjustable valve timing mechanism 19 and switching the bulb opening-and-closing timing of about four lines, the number of times of combustion is changed 1st by changing the number of times of fuel injection per cycle from a fuel injection equipment 17.

[0038] In the basis of such composition, and this invention, while being shown in drawing 2 , compressed self-ignition combustion is performed in the specific service condition below a low load and an inside rotational frequency, and jump-spark-ignition combustion is performed in a heavy load or a high rotational frequency region.

[0039] Next, operation of the gestalt of this operation is explained. Drawing 3 shows the range in which the self-ignition combustion to an air-fuel ratio is materialized. If the air-fuel ratio is made into RIN, combustion stability will get worse and an engine's torque change will become large. For this reason, the air-fuel ratio AFL from which stability permissible as the design value as an internal combustion engine or character of vehicles in which this internal combustion engine was carried serves as the stability threshold value Sth serves as a RIN limitation.

[0040] On the other hand, if the air-fuel ratio is made rich, knocking intensity will increase. Thereby, the air-fuel ratio AFR in the knocking limitation Nth serves as a rich limitation. Therefore, the air-fuel ratio field surrounded with the stability marginal air-fuel ratio AFL and the knocking marginal air-fuel ratio AFR serves as a self-ignition combustion formation range. Thus, self-ignition is materialized only in the limited air-fuel ratio range. In addition, air-fuel ratio A/F was explained to the example as an index which expresses the rate of gas and fuel here. The same inclination is shown also about the case where residual gas or EGR gas is contained, and a horizontal axis serves as the total capacity and rate G/F of fuel which doubled the burnt gas with new mind in this case.

[0041] The cycle of the usual four stroke cycle engine is shown in drawing 4 like 4 line. This is the same as the 1st [in this invention] cycle like 4 line, and the number of times of combustion is 1 time to engine 2 rotation in a shell as an intake stroke, a compression stroke, an expansion stroke, and an exhaust air line.

[0042] The usual self-ignition combustion operating range [in / cycle operation / about four lines] is shown in drawing 5 . As mentioned above, in order to prevent generating of knocking in compressed self-ignition combustion, fuel quantity sendable in a cylinder is restricted. Therefore, to engine 2 rotation, by about four lines, with a cycle engine, since there are few 1 time of opportunities which can take out work, the number of times of combustion cannot increase a load. For this reason, operation by self-ignition combustion in a heavy load region is difficult.

[0043] The cycle of a two-cycle engine is shown in drawing 6 like 2 line. The cycle of the number of times of combustion is [the inhalation-of-air compression stroke and expansion exhaust air line of about two lines] 1 time to engine 1 rotation in a shell. As shown in drawing, an exhaust valve opens from the middle of an expansion stroke, and a gas exchange is started. For this reason, work cannot fully be taken out in an expansion stroke. Moreover, since non-burned fuel is discharged, efficiency falls. Therefore, a load cannot fully be raised.

[0044] The self-ignition combustion operating range at the time of performing cycle operation of about two lines to drawing 7 is shown. A load cannot be made into double precision, although a load can be improved rather than cycle operation by about four lines and the number of times of combustion is double precision, as shown in drawing.

[0045] The 2nd [in the gestalt of this operation to drawing 8] cycle is shown like 4 line. the 2nd like [4 line] cycle -- like an inhalation-of-air compression stroke, an expansion stroke, a compression stroke, and an expansion exhaust air line -- from -- since 1st combustion is performed by the 1st fuel injection and the expansion stroke and 2nd combustion is performed like the 2nd fuel injection and an expansion exhaust air line by the compression stroke after inlet-valve valve closing [in / an inhalation-of-air compression stroke / it becomes and], the number of times of combustion per cycle becomes 2 times In

other words, the number of times of combustion is 1 time per engine 1 rotation, and is as the same as a cycle engine as two lines. Moreover, to engine 2 rotation, a gas exchange is 1 time and is the same as the cycle engine of drawing 4 like 4 line.
[0046] The component rate in the cylinder in 2nd [of the gestalt of this operation] 4 distance cycle is typically shown in drawing 9 . As mentioned above, compressed self-ignition combustion can burn also in a state [very RIN / air-fuel ratio]. Therefore, there is very little fuel quantity in an inhalation-of-air compression stroke to an air content. Moreover, in the expansion stroke which the 1st combustion ended, although a burnt gas exists, air remains [the air-fuel ratio] enough extremely for RIN. Therefore, the 2nd combustion is attained by supplying fuel by the 2nd fuel injection in a consecutive compression stroke, even if it does not carry out a gas exchange. After the 2nd combustion is completed depending a service condition, air may exist.
[0047] Drawing 10 is drawing showing the 1st and 2nd valve timing (valve lift) in cycle operation of about four lines, and indicates the 2nd like [4 line] cycle operation of the two number of times per (b) cycle of combustion to be the 1st like [4 line] cycle operation of the one number of times per (a) cycle of combustion, respectively. Thus, by switching a cam for the cam from which a cam profile differs according to 2 type ****** and an adjustable valve timing mechanism, pumping timing is changed, the 1st like [4 line] cycle operation and the 2nd like [4 line] cycle operation can be switched, and the number of times of combustion per cycle can be changed. in addition, change of valve timing -- electromagnetism -- you may use a drive bulb (Electromagnetic Valve) etc.
[0048] The 1st like [4 line] cycle operation whose number of times of combustion is 1 time, and the number of times of combustion show the self-ignition range of inflammability at the time of 2nd two 4 distance cycle operation to drawing 11 . During two combustion per cycle, by the 2nd expansion stroke both which is the 1st combustion, since an induction-exhaust valve closes and a gas exchange is not performed, by cycle operation, work of about four lines can fully be taken out.
[0049] Moreover, like the expansion exhaust air line which is the 2nd combustion, since the temperature in a cylinder and the pressure are improving by the internal EGR by the burnt gas generated by the 1st combustion, combustion makes it efficient. Moreover, while being able to burn again the unburnt fuel discharged by the 1st combustion in the elevated temperature and the high-pressure cylinder, in the 2nd combustion, generating of unburnt fuel decreases extremely. The 2nd combustion can also improve efficiency rather than the time of cycle operation by about two lines for the above reason. Consequently, in the 2nd like [4 line] cycle operation, it can increase to the abbreviation double precision of like [4 line] cycle operation of a load 1st, and self-ignition range of inflammability can be expanded to a heavy load side.
[0050] Drawing 12 is a flow chart which shows the control flow of the gestalt of this operation. An accelerator opening signal and a crank angle sensor signal are first detected at Step 10 (henceforth, S10). Subsequently, demand engine-speed N and the demand torque T are computed based on the above-mentioned detection result by S11. Subsequently, the combustion pattern of whether jump-spark-ignition combustion is performed by S12 or to perform compressed self-ignition combustion is judged.
[0051] That is, it judges whether from engine-speed N and a load T, a operating-range map as shown in drawing 11 is searched, and jump-spark-ignition combustion operation is performed, or compressed self-ignition combustion operation is performed. In performing jump-spark-ignition operation, it progresses to S13, and control of jump-spark-ignition operation is started.
[0052] In performing self-ignition operation, it progresses to S14 and starts a self-ignition combustion control. Subsequently, engine-speed N and a load T are again checked by S15. Subsequently, the number of times of combustion is judged by S16. That is, based on the map of drawing 11 , it judges [1st / 2nd] whether cycle operation of about four lines is performed, or cycle operation of about four lines is performed from engine-speed N and a load T. In other words, the number of times of combustion per cycle of about four lines is judged. When [1st] the number of times of combustion per cycle, i.e., a cycle, of about four lines is 1 time, it changes into the valve timing shown in drawing 10 (a) by S17, and control of like [4 line] cycle operation to the 1st (drawing 4) is started by S18.
[0053] When the number of times of combustion per cycle is judged to be 2 times by S16, it changes

into the valve timing shown in drawing 10 (b) by S19 similarly, and control of like [4 line] cycle operation to the 2nd (drawing 8) is started by S20.
[0054] Next, the gestalt of operation of the 2nd of this invention is explained. The 2nd composition of the gestalt of operation is shown in drawing 13 . Although the 2nd composition of the gestalt of operation is the same as that of drawing 1 which shows the composition of the gestalt of the 1st operation almost, the places where the throttle control section 6 is added to the throttle valve 21 and exhaust air system which control an air content in an inhalation-of-air system by the three way component catalyst 20 for exhaust air gas cleanups and ECU1, respectively differ to the gestalt of the 1st operation.
[0055] With the 2nd operation gestalt, while carrying out, the two sum totals of the fuel oil consumption for combustion to the 2nd air content for which an outline etc. spreads about four lines of each fuel oil consumption for two combustion per cycle at the time of cycle operation and which was inhaled in the cylinder after the gas exchange are characterized by theoretical air fuel ratio (SUTOIKI) and the bird clapper. Moreover, it is characterized by forbidding self-ignition operation, when the air-fuel ratio calculated from demand torque becomes more rich than theoretical air fuel ratio, and performing jump-spark-ignition operation.
[0056] Drawing 14 shows the component rate in the cylinder in 2nd 4 distance cycle in the gestalt of the 2nd operation. With the gestalt (drawing 9) of the 1st operation, air exists in the cylinder before the time of the 2nd combustion being completed, i.e., a gas exchange, and the inside of a cylinder has always become RIN. On the other hand, with the gestalt of the 2nd operation, when the 2nd combustion is completed, surplus air does not exist in a cylinder, but the inside of a cylinder has become theoretical air fuel ratio. Therefore, since the three way component catalyst 20 installed in the exhaust air system is efficient and works, the emission discharged from an engine can be reduced.
[0057] Moreover, as shown in drawing 14 , with the gestalt of the 2nd operation, fuel quantity of the 1st combustion and the 2nd combustion is considered as outline regularity. Therefore, since the torque acquired by the 1st combustion and the 2nd combustion becomes equal, a **** performance is further and it can raise operability more.
[0058] With the form of the 2nd operation, the rate of the fuel gas in a cylinder serves as outline regularity. If the air-fuel ratio of theoretical air fuel ratio is set to 14.5, the air-fuel ratio at the time of the 1st combustion will be set to 29. In the 2nd continuing combustion, since fuel quantity is fixed, although it is set to 29, the rate, i.e., G/F, of gas and fuel, it is set to 14.5, the ratio, i.e., A/F, to an air content. Thus, with the form of the 2nd operation, since the fuel quantity to capacity is fixed, control of a load is performed by controlling an air content by the throttle valve 21. In addition, as for an air-fuel ratio, at the time of compressed self-ignition operation, there are many air contents because of RIN, and there are few pumping losses generated by the throttle valve.
[0059] Drawing 15 is a flow chart which shows the control flow of the gestalt of the 2nd operation. Although the control flow of the gestalt of the 2nd operation is the same as that of the gestalt (drawing 12) of the 1st operation almost, after the number of times of combustion per cycle is judged to be 2 times by S16, the control after changing into the 2nd valve timing which was suitable for the cycle about four lines by S19 differs.
[0060] That is, demand engine-speed N and a load T are checked by S30 following S19. Subsequently, asks for the throttle opening TVO from the map of drawing 16 based on the demand load T by S31, a control signal is sent to a throttle 21 from the throttle control section 6, and a throttle 21 is set to the throttle opening TVO for which it asked on the map.
[0061] Subsequently, the inhalation air content Q is detected by S32. Subsequently, fuel quantity F is computed from the map of drawing 17 based on engine-speed N and the inhalation air content Q by S33. Thus, while making the 2nd air-fuel ratio [in / a cycle / about four lines] per each 4 distance cycle into theoretical air fuel ratio by controlling, in each combustion cycle, the ratio of gas and fuel can control to about 29. That is, while realizing desired torque, it becomes possible to make it burn in a RIN air-fuel ratio.
[0062] Next, the gestalt of operation of the 3rd of this invention is explained. The 3rd composition of the

gestalt of operation is shown in drawing 18 . Although the 3rd composition of the gestalt of operation is the same as the composition (drawing 13) of the gestalt of the 2nd operation almost, the places where a supercharger 22 is added to an inhalation-of-air system to the gestalt of the 2nd operation at, and the charge pressure control section 7 is added to ECU1 differ.
[0063] The gestalt of the 3rd operation is characterized by the place which is controlled also about charge pressure P in addition to the throttle opening TVO to the demand load T. That is, the demand load T is large, when a throttle is opened fully, air contents run short, when the two sum totals of the oil consumption for combustion to the inhalation air content in a cylinder per cycle become more rich than theoretical air fuel ratio, charge pressure P is made to increase, and an air-fuel ratio is controlled to theoretical air fuel ratio by increasing an air content. Moreover, when charge pressure P is made to increase, the efficiency of the gas exchange of a burnt gas and new mind improves. For this reason, the residual gas which remains in a cylinder decreases, since the rate of new mind of entering in a cylinder also increases, fuel quantity can be made to be able to increase further and a self-ignition combustion zone can be made to expand also to a bigger demand load.
[0064] The self-ignition formation range at the time of increasing charge pressure P to drawing 19 is shown. A self-ignition operating range is further expandable to a heavy load side from the 2nd operation gestalt by performing charge pressure control to throttle opening (TVO) control.
[0065] Drawing 20 is a flow chart which shows the control flow of the gestalt of the 3rd operation. Although the control flow of the gestalt of the 3rd operation is the same as that of drawing 15 which shows the gestalt of the 2nd operation almost, operation after valve timing change of S19 differs.
[0066] That is, in drawing 20 , demand engine-speed N and the demand load T are checked by S50 following S19. Engine-speed N, the field which performs throttle opening TVO control from the map of drawing 19 based on a load T, and the field which performs charge pressure P control is judged by S51. When performing charge pressure P control, charge pressure control is performed based on the demand load T by S52. This is performed using the map of the charge pressure P to the demand load T prepared for each [as shown in drawing 21] the engine rotation of every. Although a demand load is [constant value] constant value with small charge pressure, or 0 so that clearly from drawing 21 , if the demand load T exceeds constant value, in proportion to the increment of a demand load, the increment of required charge pressure will become large.
[0067] When judged as throttle opening TVO control by S51, based on the demand load T, the throttle opening TVO is controlled by S53. Subsequently, the inhalation air content Q is detected by S54, and fuel oil consumption F is computed from engine-speed N and the inhalation air content Q by S55.
[0068] Thus, by controlling the throttle opening TVO and charge pressure P, a self-ignition operating range is further expandable to a heavy load side.
[0069] Next, the gestalt of operation of the 4th of this invention is explained. The 4th composition of the gestalt of operation is the same as the composition of the gestalt of the 1st operation shown in drawing 1 .
[0070] It is characterized by for the gestalt of the 4th operation being able to switch the usual jump-spark-ignition combustion according to a cycle about four lines, the usual compressed self-ignition combustion according to a cycle about four lines, and compressed self-ignition combustion according to a cycle about six lines according to operational status, making the gas exchange of about six lines into 1 time into a cycle, and the number of times of combustion considering as 3 times.
[0071] The cycle in the gestalt of the 4th operation is shown in drawing 22 like 6 line. this like [6 line] cycle -- like an inhalation-of-air compression stroke -> expansion-stroke -> compression stroke -> expansion-stroke -> compression stroke -> expansion exhaust air line -- from -- it becomes And the gas exchange in a cycle of about six lines is 1 time. Moreover, the number of times of combustion is 1/2 of the number of stroke which becomes a total of 3 times of 2 times of expansion strokes, and 1 time of an exhaust air expansion stroke into a cycle about six lines, namely, constitutes a cycle.
[0072] The valve timing (valve lift) of the gestalt of the 4th operation is shown in drawing 23 (b). Even if the number of times of combustion shown in this drawing (a) compares with the gestalt of the 1st operation which is 2 times, it turns out that there is little number of times of a gas exchange to the

number of times of combustion. Thus, the combustion cycle of about six lines of about four lines can be changed into a cycle from a cycle changing the cam from which a cam profile differs, or by changing the reduction gear ratio from a crankshaft rotational frequency to a cam shaft rotational frequency. moreover, change of valve timing -- electromagnetism -- you may use a drive bulb etc.
[0073] Moreover, with the gestalt of this operation, to the three number of times of combustion, since 1 time and the number of times have few gas exchanges, eccrisis of a unburnt gas can be reduced. Moreover, since combustion continues 3 times following one gas exchange, in the combustion which is the 2nd time and the 3rd time, the pressure in a cylinder and temperature are rising by the burnt gas. For this reason, since fuel becomes easy to burn, the unburnt gas which occurs in combustion process can be reduced. A unburnt gas can be reduced according to these two effects.
[0074] The component rate in a cylinder of the gestalt of the 4th operation is typically shown in drawing 24 . In self-ignition combustion, since fuel can make it burn in a few RIN state, even if the number of times of combustion continues 3 times, air exists enough.
[0075] Although the control flow of the gestalt of the 4th operation is the same as that of the gestalt of the 1st operation shown in drawing 12 almost While the number-of-times judgment of combustion of S16 is changed into what judges 1 time or 3 times When judged as 3 times, it changes to the 2nd like [4 line] cycle control start by moving to S19, and S20, and only a cycle control start, the bird clapper and the cam to be used, or the control timing of an electro-magnetic valve of about six lines is different.
[0076] In addition, although the gestalt of this operation explained the cycle of about six lines to the example, the same thing can be considered when the number of processes per cycle is eight or more lines about. in this case, before [like an expansion exhaust air line] -- further -- expansion (combustion) distance and a compression stroke -- multiple times -- it will be repeated
[0077] Next, the gestalt of operation of the 5th of this invention is explained. The 5th composition of the gestalt of operation is the same as the composition of the gestalt of the 2nd operation shown in drawing 13 .
[0078] With the gestalt of the 5th operation, to the gestalt of the 4th operation, an outline etc. spreads the fuel quantity of each combustion in combustion of the multiple times corresponding to one gas exchange, and it is characterized by making the sum total of the fuel quantity for combustion of the multiple times to the amount of inhalation of air after a gas exchange into theoretical air fuel ratio further.
[0079] The component rate in a cylinder of the gestalt of the 5th operation is typically shown in drawing 25 . With the gestalt of the 5th operation, the fuel quantity of three combustion is equal and the total value of the fuel quantity for combustion of three batches to the air content inhaled in the cylinder by the inhalation-of-air compression stroke of drawing 25 (a) serves as theoretical air fuel ratio. If this puts in another way, the air-fuel ratio at the time of the 3rd combustion in the compression stroke of drawing 25 (e) is theoretical air fuel ratio. Therefore, excessive air does not exist at the time of the gas exchange depended like the expansion exhaust air line of drawing 25 (f), but all become a burnt gas.
[0080] If theoretical air fuel ratio is set to 14.5, in the 1st combustion, the rate (G/F) of gas and fuel is about 43.5. At this time, it is also an air-fuel ratio (A/F) 43.5 [about]. In the 2nd combustion, G/F is about 43.5 and A/F is set to about 29. In the 3rd combustion, G/F is about 43.5, and A/F is about 14.5.
[0081] Thus, the torque acquired from each combustion by each combustion since G/F is fixed becomes fixed, and it can prevent spoiling operability. Moreover, since the three way component catalyst installed in the exhaust air system since the air-fuel ratio at the time of the combustion before a gas exchange was theoretical air fuel ratio is efficient and works, the emission discharged from an engine can be reduced.
[0082] Although the control flow of the gestalt of the 5th operation is the same as that of the gestalt of the 2nd operation shown in drawing 15 almost, while the number-of-times judgment of combustion of S16 was changed into what judges 1 time or 3 times, when it is judged as 3 times, moving to S19 and the cam to be used differ only from the control timing of an electro-magnetic valve.
[0083] In addition, although the gestalt of this operation explained the cycle of about six lines to the example, the same thing can be considered when the number of stroke of about eight lines per cycle is

more than a number. in this case, before [like an expansion exhaust air line] -- further -- an expansion stroke and a compression stroke -- multiple times -- it will be repeated Moreover, if it puts in another way so that the sum total of the fuel quantity for combustion of the multiple times to the amount of inhalation of air after a gas exchange may serve as theoretical air fuel ratio in that case, the air-fuel ratio before a gas exchange will control fuel quantity to become theoretical air fuel ratio.
[0084] furthermore, the internal combustion engine with which the service conditions for a generator drive etc. are limited to the comparatively narrow range -- setting -- the usual like [4 line] cycle operation -- not carrying out -- the [the 4th and] -- it can be made to be able to work only by operation of the cycle of 5 operation gestalten which has the cycle or six or more numbers of stroke of about six lines, and curtailment of specific fuel consumption and purification of exhaust air can be realized by the high level

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[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram of the 1st operation gestalt of the combustion control system of the internal combustion engine concerning this invention.
[Drawing 2] It is drawing explaining the combustion pattern to a service condition.
[Drawing 3] It is drawing explaining the self-ignition combustion formation range.
[Drawing 4] It is the 1st drawing explaining the cycle (like [4 line] cycle of the one number of times of combustion) of about four lines.
[Drawing 5] It is the 1st drawing explaining the self-ignition combustion formation range of a cycle of about four lines.
[Drawing 6] It is drawing explaining the cycle of about two lines.
[Drawing 7] It is drawing explaining the self-ignition combustion formation range of a cycle of about two lines.
[Drawing 8] It is the 2nd drawing explaining the cycle (like [4 line] cycle of the two number of times of combustion) of about four lines.
[Drawing 9] It is the 2nd drawing explaining the component rate in a cylinder of a cycle of about four lines.
[Drawing 10] It is drawing explaining valve timing.
[Drawing 11] It is the 2nd drawing explaining the self-ignition combustion formation range of a cycle of about four lines.
[Drawing 12] It is a flow chart explaining operation of the gestalt of the 1st operation.
[Drawing 13] It is the block diagram of the gestalt of the 2nd operation.
[Drawing 14] It is drawing explaining the component rate in a cylinder of the gestalt of the 2nd operation.
[Drawing 15] It is a flow chart explaining operation of the gestalt of the 2nd operation.
[Drawing 16] It is drawing explaining the throttle opening TVO to the demand load T.
[Drawing 17] It is drawing explaining the fuel oil consumption F to amount Q/N of inhalation of air per rotation.
[Drawing 18] It is the block diagram of the gestalt of the 3rd operation.
[Drawing 19] It is drawing explaining the self-ignition combustion formation range of the gestalt of the 3rd operation.
[Drawing 20] It is a flow chart explaining operation of the gestalt of the 3rd operation.
[Drawing 21] It is drawing explaining the charge pressure to a demand load.
[Drawing 22] It is drawing explaining the cycle of about six lines of the gestalt of the 4th operation.
[Drawing 23] It is drawing explaining the valve timing of the gestalt of the 4th operation.
[Drawing 24 </A>] It is drawing explaining the component rate in a cylinder of the gestalt of the 4th operation.
[Drawing 25] It is drawing explaining the component rate in a cylinder of the gestalt of the 5th operation.

[Description of Notations]
1 ECU
2 Combustion Pattern Judging Section
3 Jump-Spark-Ignition Combustion-Control Section
4 Self-ignition Combustion-Control Section
5 Cycle Change Control Section
10 Engine
11 Inhalation-of-Air Bulb
12 Exhaust Air Bulb
13 Piston
14 Inhalation Air-Content Sensor
15 Crank Angle Sensor
17 Fuel Injection Equipment
18 Ignition Plug
19 Adjustable Valve Timing Mechanism
20 Three Way Component Catalyst
21 Throttle Valve
22 Supercharger

[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1] Have in a cylinder the fuel direct injection equipment which injects direct fuel, and the good change valve gear which can change the opening-and-closing stage of an induction-exhaust valve, and it sets according to a service condition to the internal combustion engine which can switch compressed self-ignition combustion and jump-spark-ignition combustion. like an intake stroke, a compression stroke, an expansion stroke, and an exhaust air line -- from -- with the 1st becoming like [4 line] cycle operation An inhalation-of-air compression stroke, an expansion stroke, a compression stroke, and the combustion control system of the internal combustion engine characterized by the 2nd thing to which an expansion exhaust air line performs two combustion of about four lines into a cycle in a shell, and for which the switch of cycle operation of about four lines was enabled at the time of compressed self-ignition combustion.
[Claim 2] It is the combustion control system of the internal combustion engine according to claim 1 characterized by the two aforementioned sum totals of the fuel oil consumption for combustion being [of about four lines] the fuel oil consumption according to target torque of the above 2nd at the time of cycle operation.
[Claim 3] The combustion control system of the internal combustion engine according to claim 1 or 2 with which the two aforementioned sum totals of the fuel oil consumption for combustion to the air content of the above 2nd inhaled in the cylinder by the end of the aforementioned inhalation-of-air compression stroke at the time of cycle operation are characterized by the theoretical air fuel ratio and the bird clapper of about four lines.
[Claim 4] The combustion control system of the internal combustion engine according to claim 1 or 2 with which the two aforementioned sum totals of the fuel oil consumption for combustion to the air content of the above 2nd inhaled in the cylinder by the end of the aforementioned inhalation-of-air compression stroke at the time of cycle operation are characterized by the stratification air-fuel ratio and bird clapper of about four lines.
[Claim 5] The combustion control system of the internal combustion engine of the claim 1 characterized by switching to the usual jump-spark-ignition combustion from compressed self-ignition combustion when torque is further required rather than the amount from which the two aforementioned sum totals of the fuel oil consumption for combustion to the air content of the above 2nd inhaled in the cylinder by the end of the aforementioned inhalation-of-air compression stroke at the time of cycle operation of about four lines serve as theoretical air fuel ratio, or a claim 4 given in any 1 term.
[Claim 6] The combustion control system of the internal combustion engine of the claim 1 which is further equipped with a supercharge means to supercharge inhalation of air, and the charge pressure control means which control the charge pressure of this supercharge means, and is characterized by the thing of about four lines of the above 2nd for which the aforementioned charge pressure control means control charge pressure so that the air-fuel ratio in a cylinder turns into theoretical air fuel ratio at the time of cycle operation, or a claim 5 given in any 1 term.
[Claim 7] The combustion control system of the internal combustion engine characterized by to have in

a cylinder the fuel direct-injection equipment which injects direct fuel, and the good change valve gear which can change the opening-and-closing stage of an induction-exhaust valve, to make opening and closing of the pumping bulb for performing a gas exchange into the aforementioned cycle into 1 time in the internal combustion engine which performs operation which has the distance of six or more lines per 1 cycle about, and to set the number of times of combustion to one half of the numbers of stroke per aforementioned cycle.

[Claim 8] The combustion control system of the internal combustion engine according to claim 7 characterized by the thing of about six lines for which the sum total of the fuel oil consumption per [to the air content in a cylinder after a gas exchange] 1 cycle was made into theoretical air fuel ratio at the time of operation more than a cycle by compressed self-ignition combustion.

[Claim 9] The combustion control system of the internal combustion engine according to claim 7 characterized by the thing of about six lines for which the sum total of the fuel oil consumption per [to the air content in a cylinder after a gas exchange] 1 cycle was made into the stratification air-fuel ratio at the time of operation more than a cycle by compressed self-ignition combustion.

[Translation done.]

* NOTICES *

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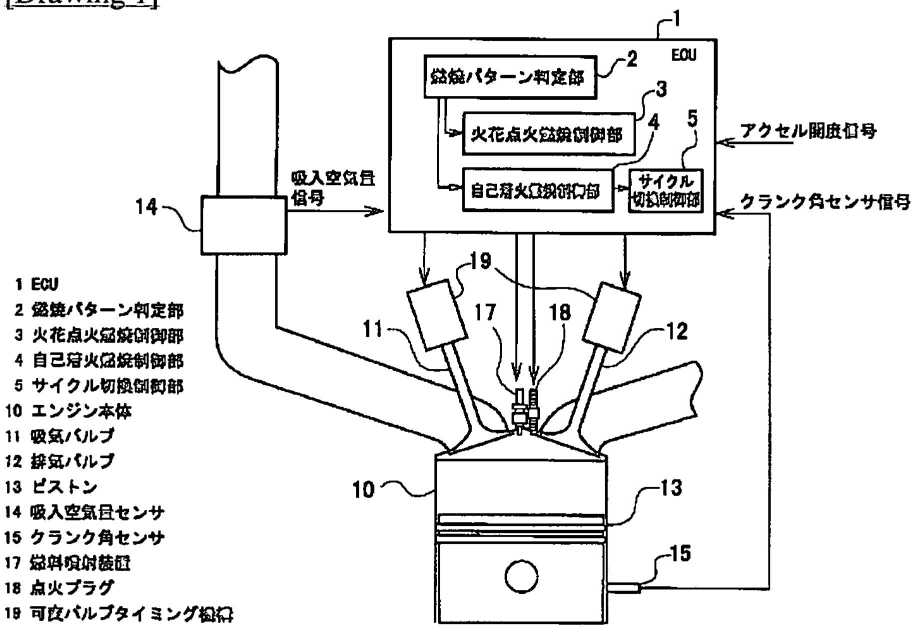
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]



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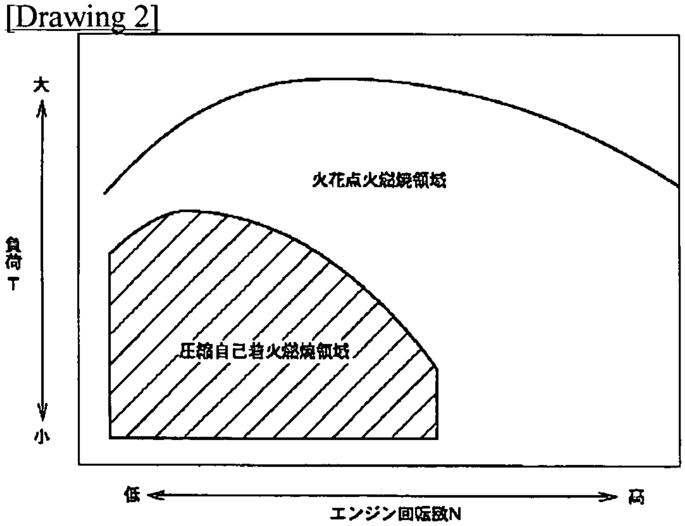

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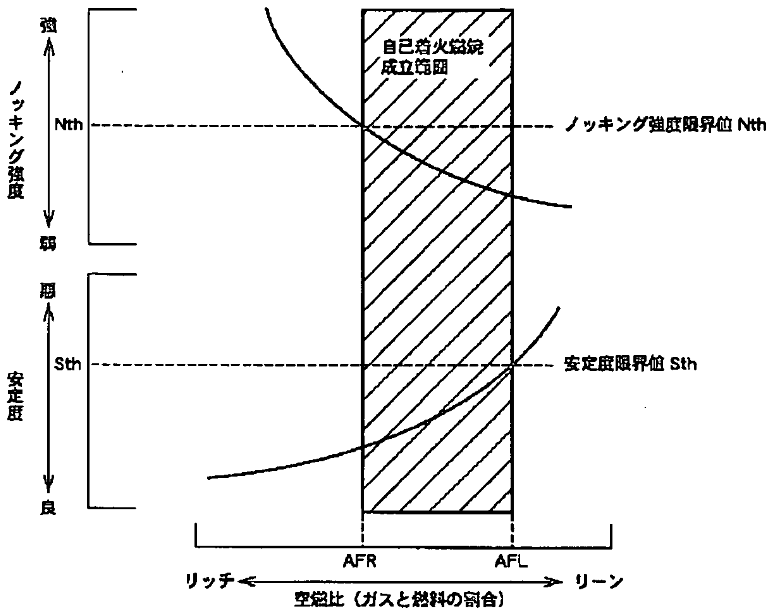

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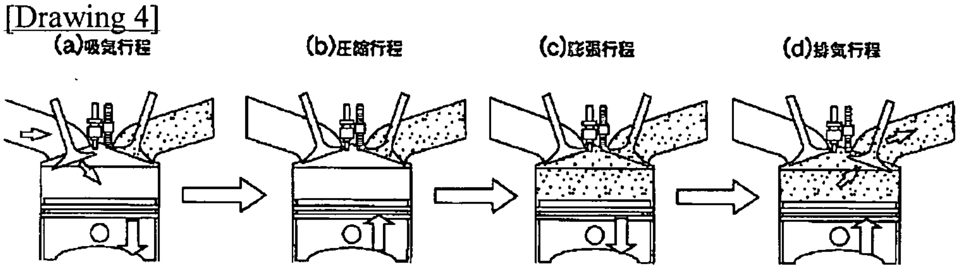

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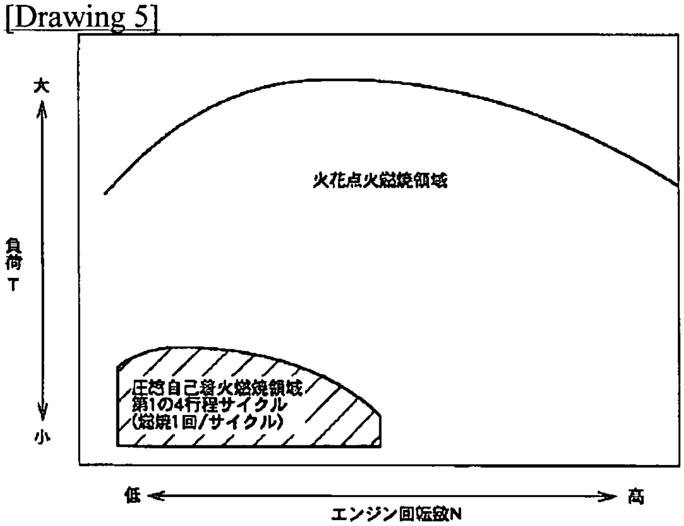

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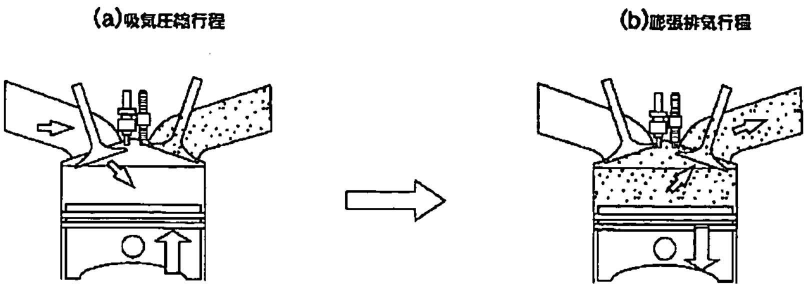

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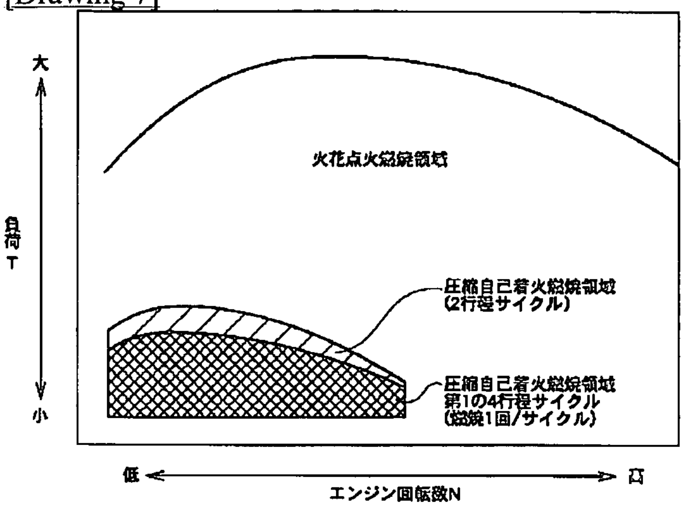

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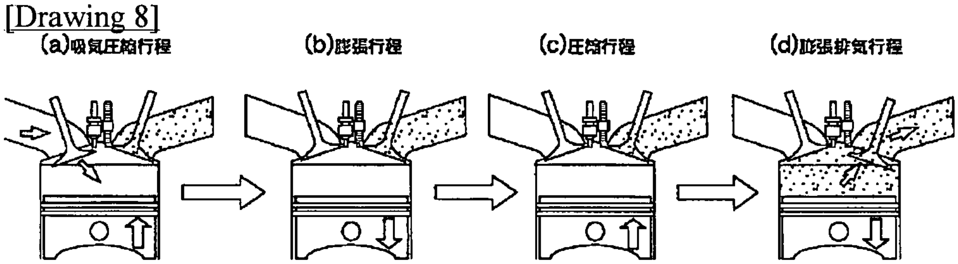

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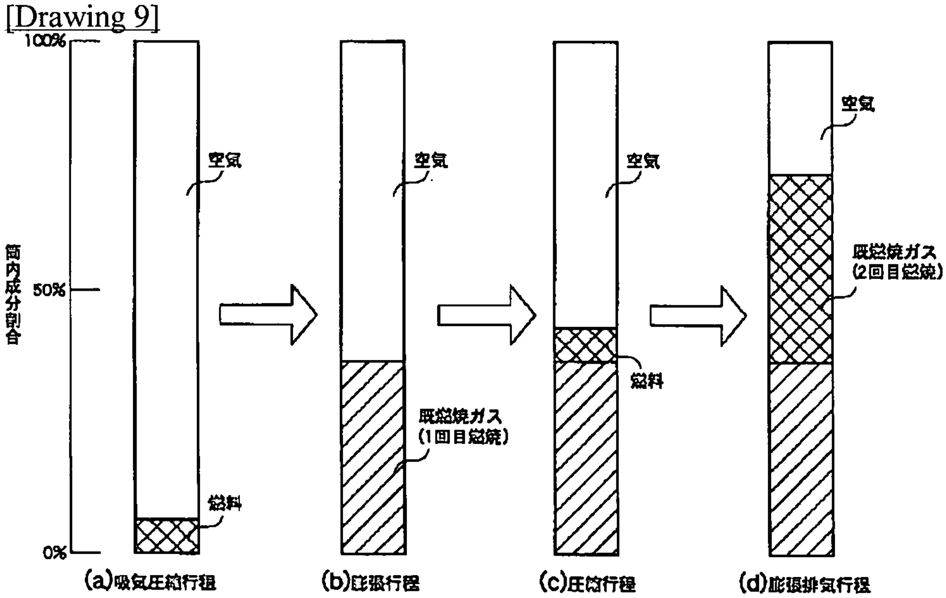

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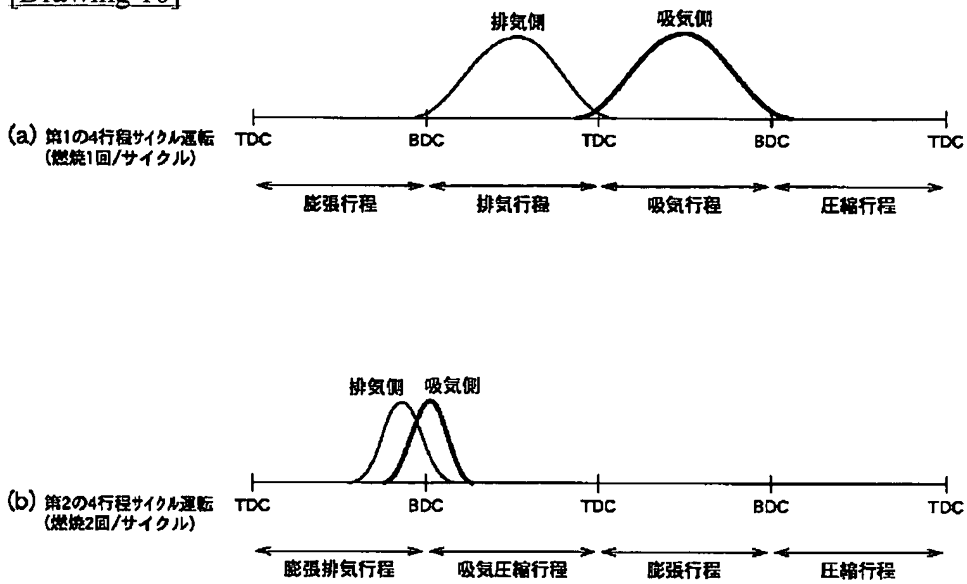

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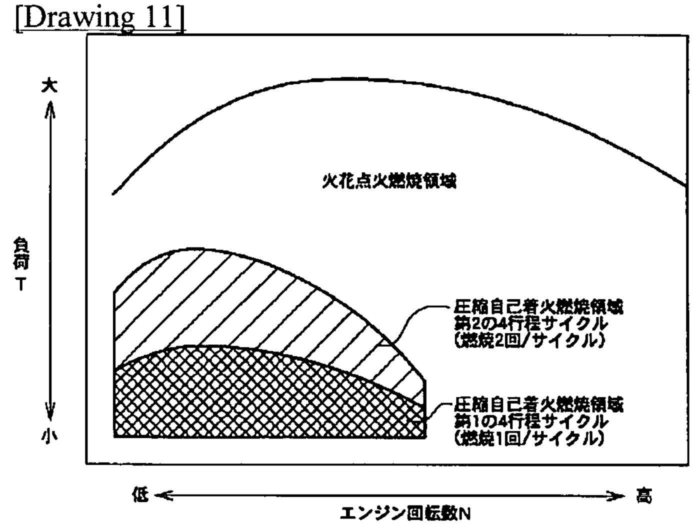

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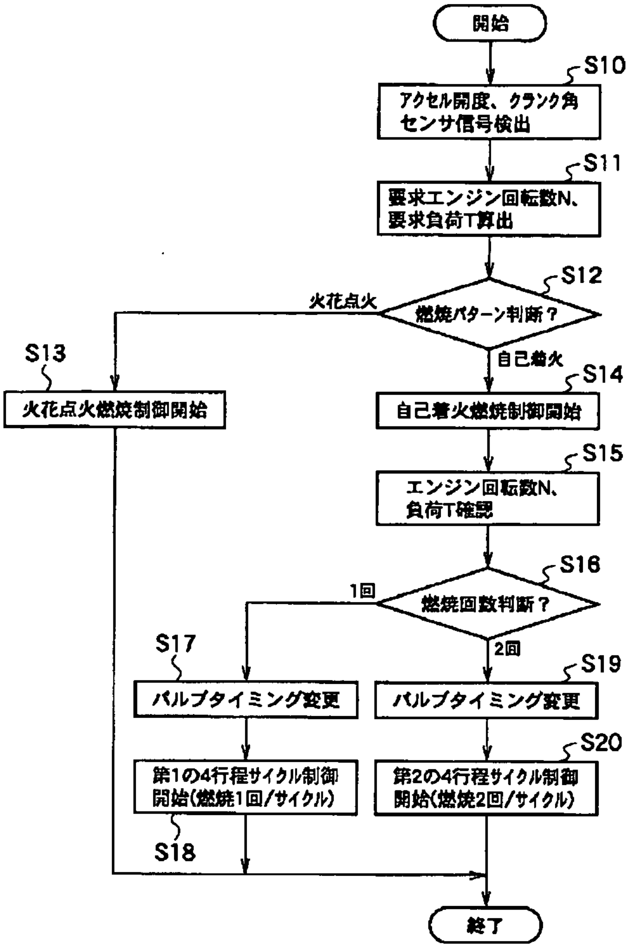

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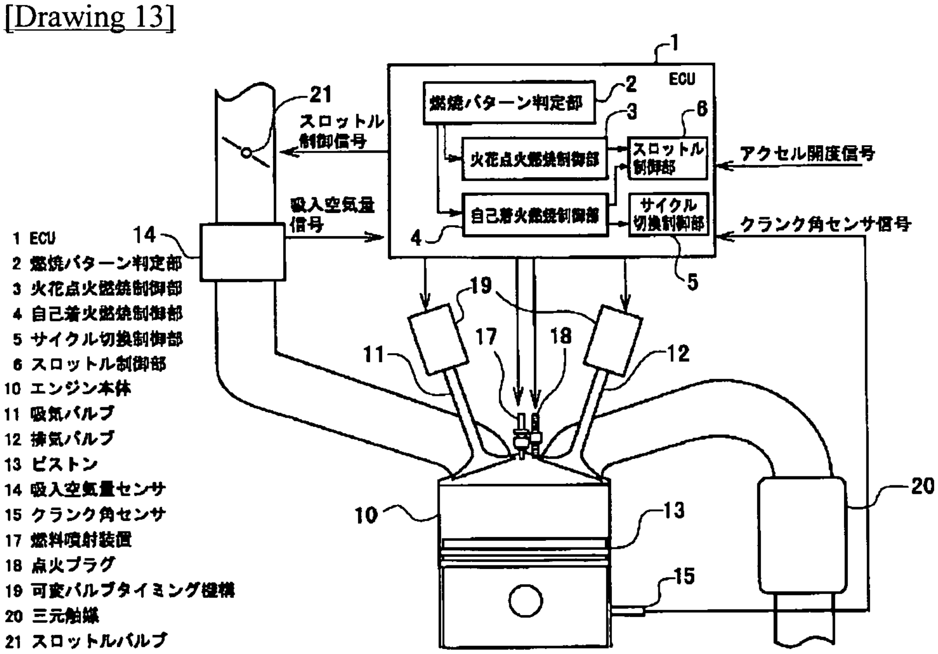

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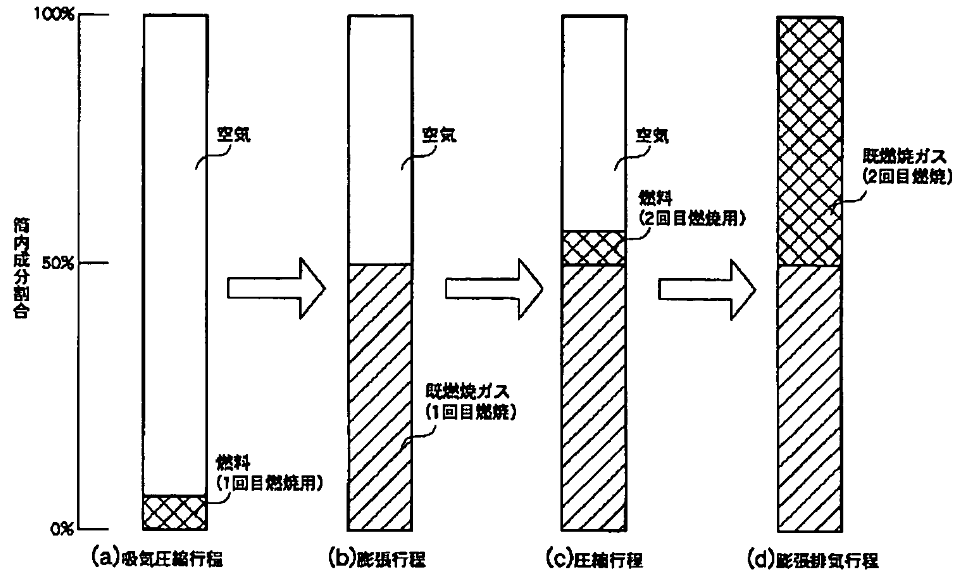

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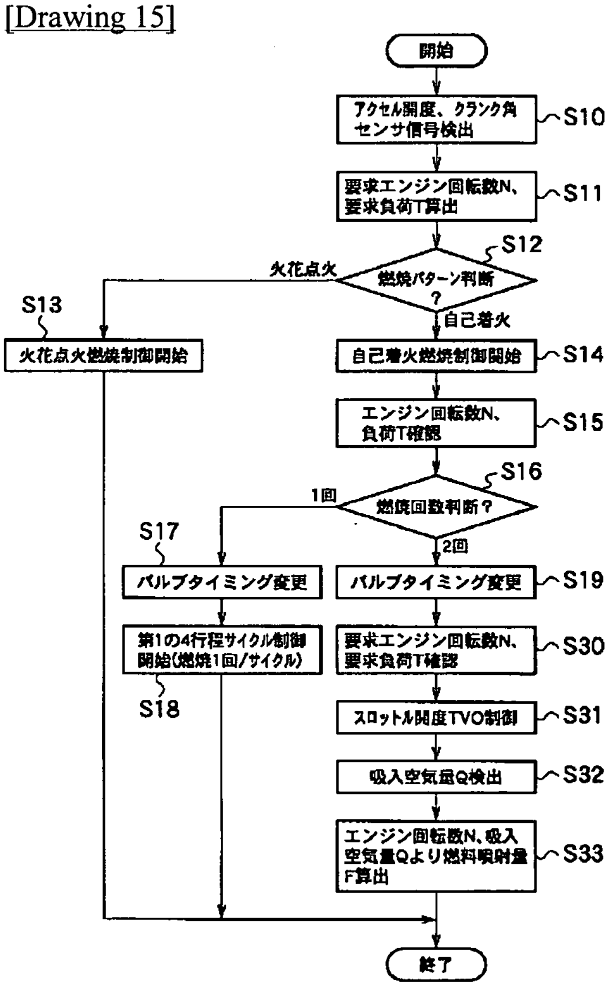

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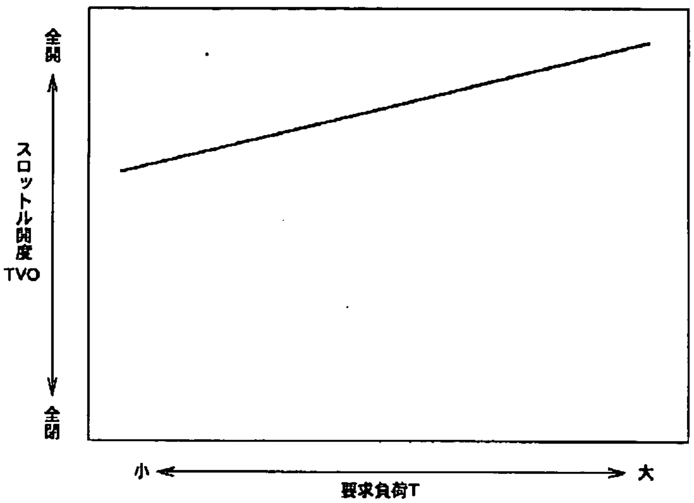

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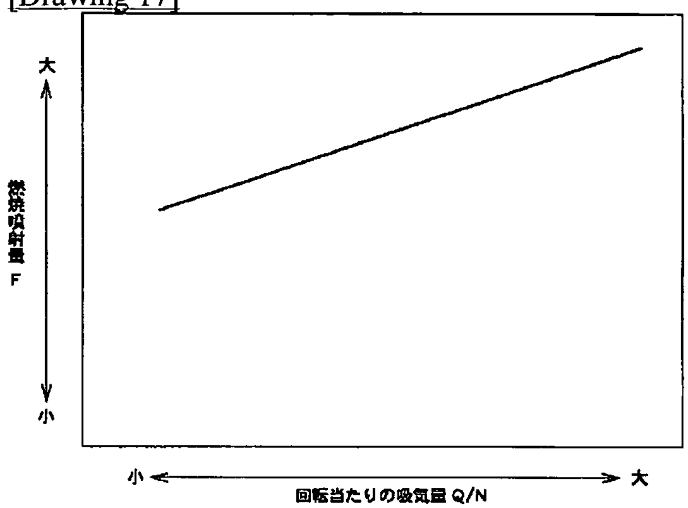

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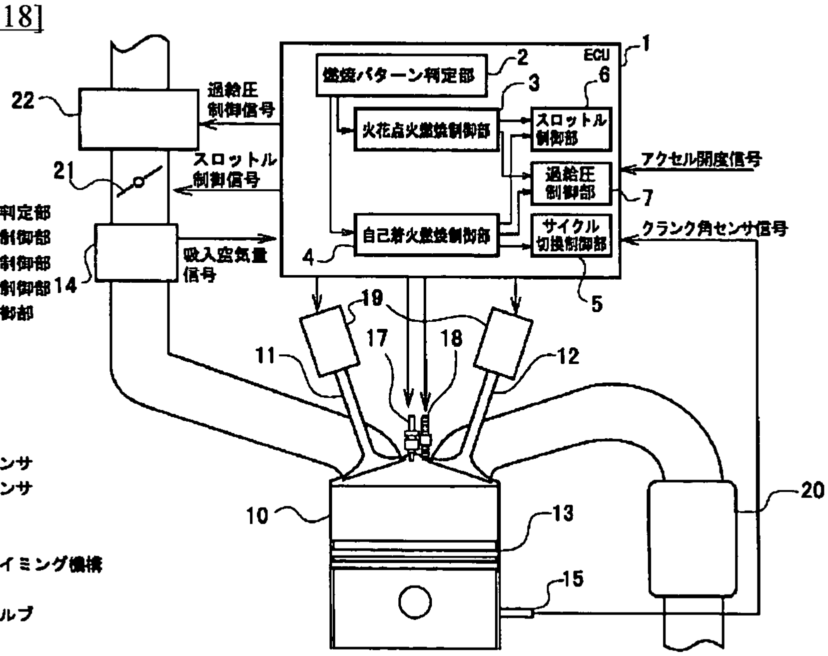
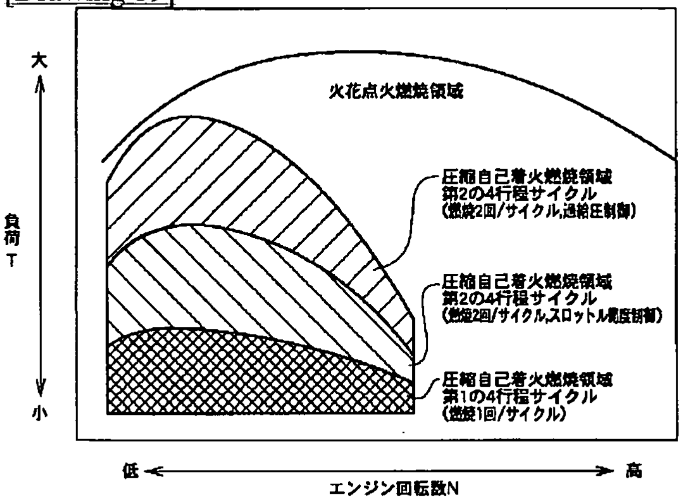


1 ECU
2 燃焼パターン判定部
3 火花点火燃焼制御部
4 自己着火燃焼制御部
5 サイクル切換制御部
6 スロットル制御部
7 過給圧制御部
10 エンジン本体
11 吸気バルブ
12 排気バルブ
13 ピストン
14 吸入空気量センサ
15 クランク角センサ
17 燃料噴射装置
18 点火プラグ
19 可変バルブタイミング機構
20 三元触媒
21 スロットルバルブ
22 過給機

[Drawing 19]



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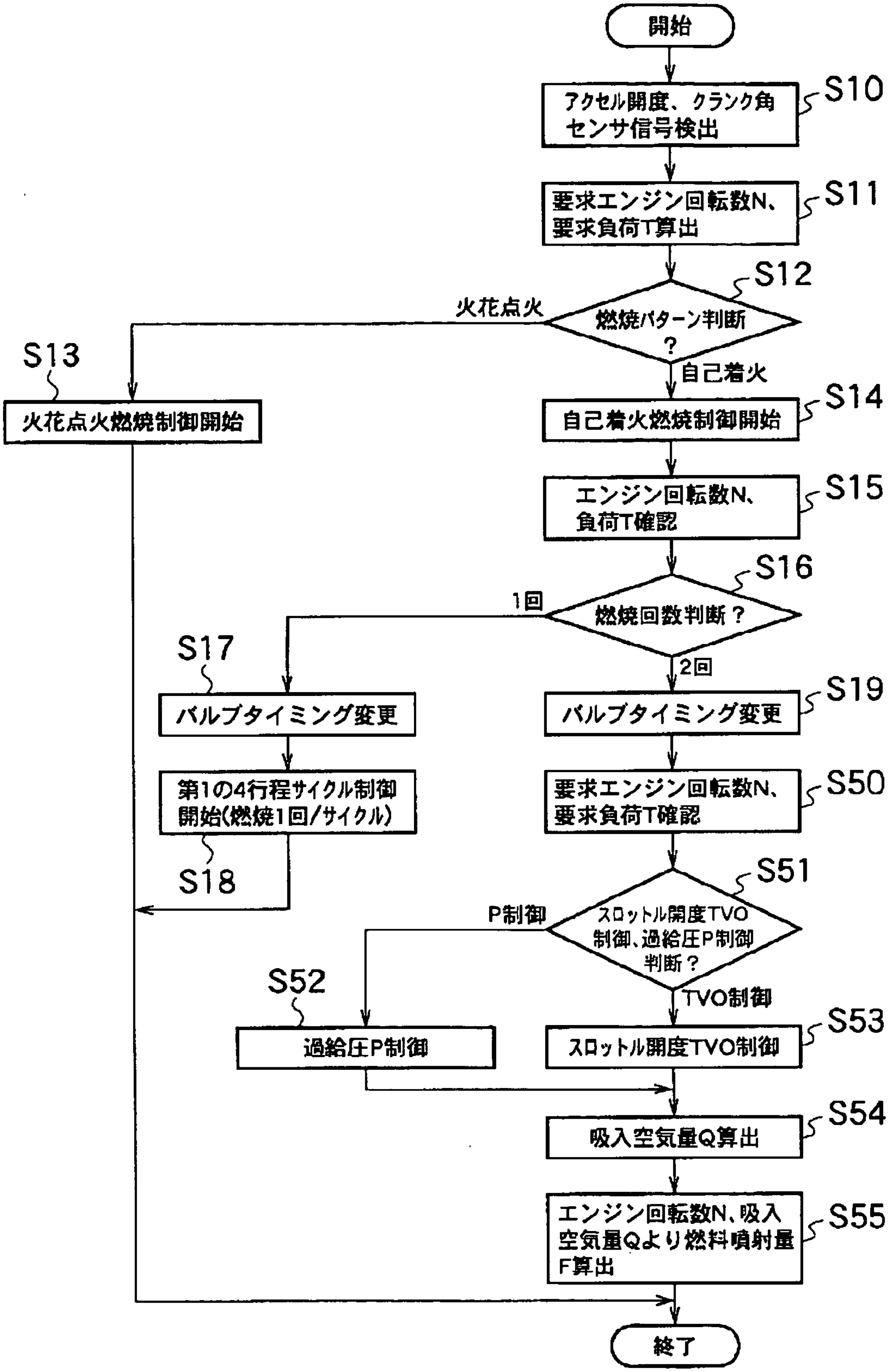
開始
アクセル開度、クランク角センサ信号検出
S10
要求エンジン回転数N、要求負荷T算出
S11
燃焼パターン判断?
S12
火花点火
自己着火
S13
火花点火燃焼制御開始
自己着火燃焼制御開始
S14
エンジン回転数N、負荷T確認
S15
燃焼回数判断？
S16
1回
2回
S17
バルブタイミング変更
第1の4行程サイクル制御開始(燃焼1回/サイクル)
S18
バルブタイミング変更
S19
要求エンジン回転数N、要求負荷T確認
S50
スロットル開度TVO制御、過給圧P制御判断？
S51
P制御
TVO制御
S52
過給圧P制御
スロットル開度TVO制御
S53
吸入空気量Q算出
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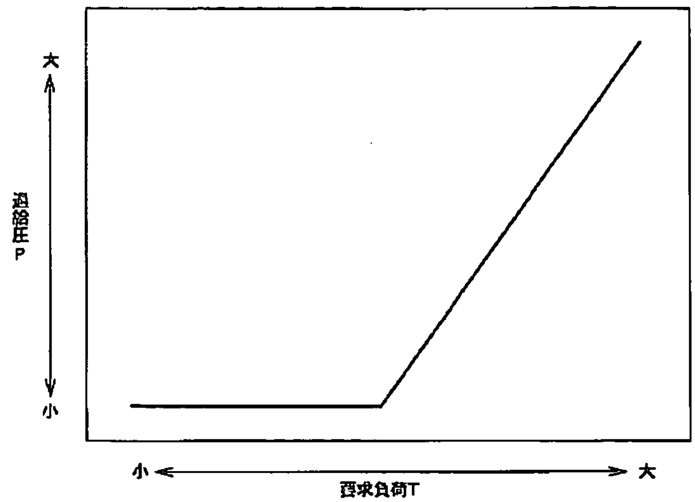
エンジン回転数N、吸入空気量Qより燃料噴射量F算出
S55
終了

[Drawing 21]



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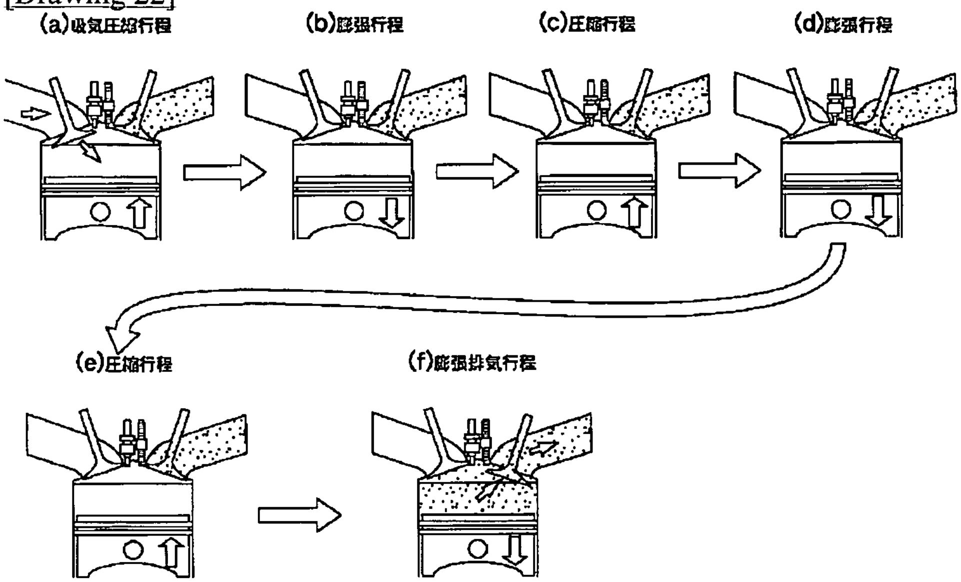

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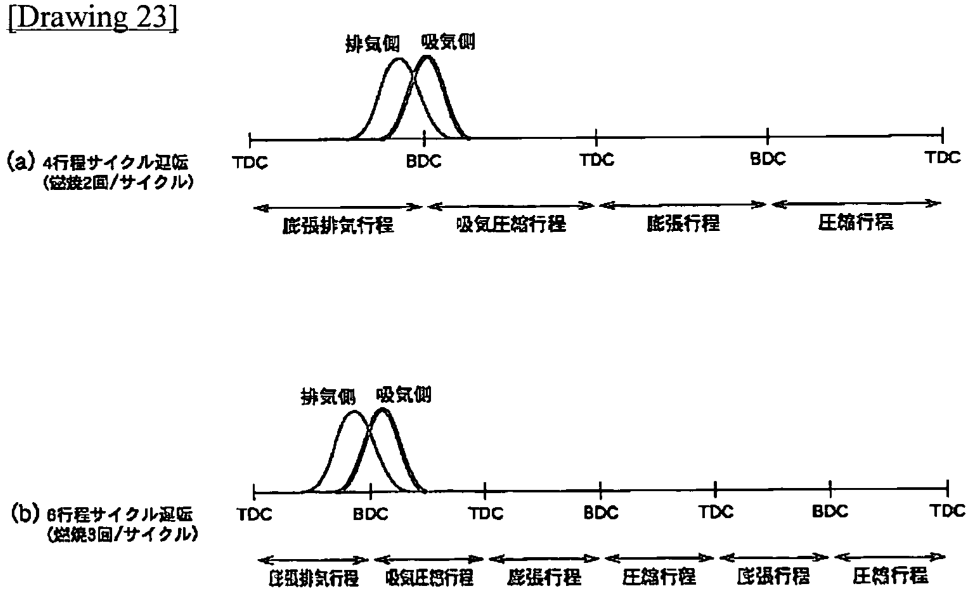

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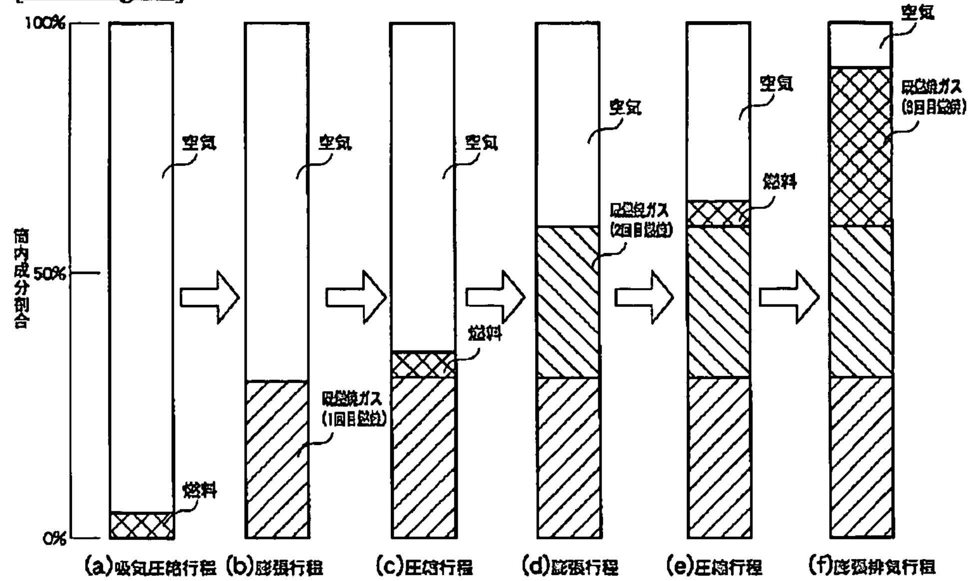

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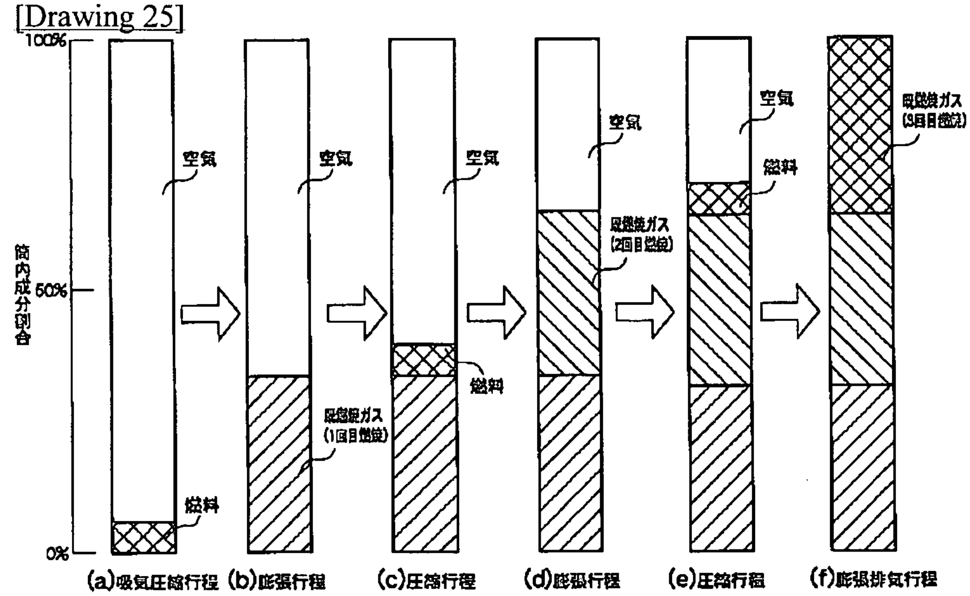

[Translation done.]